4. TECHNOLOGY ASSESSMENT

4.1 Introduction

Up to this point, we have accomplished two very important tasks. First, by completing a thorough review of all pertinent government furnished information (GFI), and visits to several Coast Guard shore and mobile commands, we have documented the Coast Guard’s telecommunication system baseline (as-is) architecture (described in Chapter 2). This effort was followed by a set of detailed interviews with key Headquarters Program Managers and Staff, which complemented the research and analysis that was accomplished in Chapter 2. From this, we developed a comprehensive list of future telecommunications requirements which are provided in Chapter 3.

In this chapter, we will assess several technology areas: (1) Data Networking, (2) Mobile Communications, and (3) Requirements for Interoperability with DoD. We will analyze networking technologies at a high level just to determine their potential for addressing current and future requirements, and their impacts on the Coast Guard’s future architecture. We will assess the relevant technologies and develop a list of alternative solutions, and future architectures, capable of satisfying Program Manager requirements. For each technology, we will answer three very important questions: What is it? What will it do for the Coast Guard? And, What is a rough estimate of its cost? The list of alternatives will be analyzed more completely in the next Chapter of the TCP.

Within the telecommunications system, there exists several dedicated networks to serve the Aviation, Communication Station, and Radionavigation communities. The choice of standards and architecture for the Coast Guard network will consider these networks. A good choice of Coast Guard network systems will allow these dedicated networks to seemlessly migrate onto the standard Coast Guard network. This should result in lower operating, training, and maintenance costs, while meeting these systems standards for survivability and reliability.

4.2 Data Networking Alternatives

In this section, we will discuss several alternatives for meeting the Coast Guard’s current and future data networking requirements. These alternatives, which encompass both dedicated and on-demand networking connections, include X.25, Asynchronous Transfer Mode (ATM), Frame Relay, Integrated Services Digital Network (ISDN), Point-to-Point networking services, and Very Small Aperture Terminal (VSAT) networking. It is important to keep in mind, while planning the future network architecture, that the Defense Message System (DMS) is a requirement that will have a considerable impact on the Coast Guard’s data networking solution. DMS implementation is scheduled to begin in 1997 as the backbone infrastructure is developed and activities involved in initial test and evaluation of DMS contract products begin to cut over. The expected service-wide cutover date is 1999. DMS will be discussed in greater detail later on in this section.

For each alternative, overall operating costs (where available) include circuit installation charges and basic monthly rates, along with equipment purchase costs. Costs were determined using a sample network configuration consisting of two remote units (Atlantic and Pacific Area) connected to a central site (OSC Martinsburg). This limited network architecture is considered adequate for high-level cost comparison purposes. More detailed life-cycle costong of selected alternatives will be accomplished in Chapter 5.

(Note: It is understood that telecommunication costs and system availability in Alaska and Hawaii may differ from CONUS networking solutions.

Wherever it is cost effective and possible, the network will be designed to minimize single point failures, critical nodes, and to ensure the highest reliability and survivability practical. This is especially important due to the nature of Coast Guard missions—the demand for services is greatest in times of disaster, such as earthquakes, hurricanes, and floods. It is at these very times that the widespread unavailability of traditional communications is most likely. This should allow us to effectively weigh, later on in the TCP, the potentials and costs of matrixed systems, back-up options, and fully diverse systems. The costing issues of selected alternatives will be discussed in greater detail in Chapter 5.

4.2.1 Packet-Switched Data Network

The current Coast Guard Data Network (CGDN) is an X.25 packet-switched data communications network connecting all large and most small Coast Guard units. The CGDN provides the primary transmission media for day-to-day, unclassified individual (electronic mail) and organizational record communications. It consists of both leased circuits and Coast Guard owned and leased switching facilities.

Data transaction communications is accomplished by either imbedding the transaction in the mail message or attaching a file of transactions to the message. Using the X.25 protocol, a single message is broken into packets which are transmitted when circuit time is available and re-assembled at the receiving end to reconstitute the message. The X.25 software protocol assigns identifiers to each message packet to enable correct reassembly at the receiving end. Error correction is built into the X.25 protocol, since packet-switched networks are relatively noisy. This adds to the overhead for each packet transmitted over the network. X.25 was designed in an era of data communications speeds of 300 to 1200 bps. Older switches, built for this protocol, have a capacity to handle bandwidths of up to 56 kbps. To obtain higher bandwidths, older switches need to be replaced with newer ones.

The CGDN consists of 56 kbps circuits connecting major nodes (Figure 4-1) located at Coast Guard Headquarters, Area and District Offices, and the Operations Systems Center (OSC). This portion of the network is called the backbone. Each major node (except Districts 14 and 17) is connected to at least two other nodes by these high speed circuits to ensure alternate routing in case of a single circuit failure.

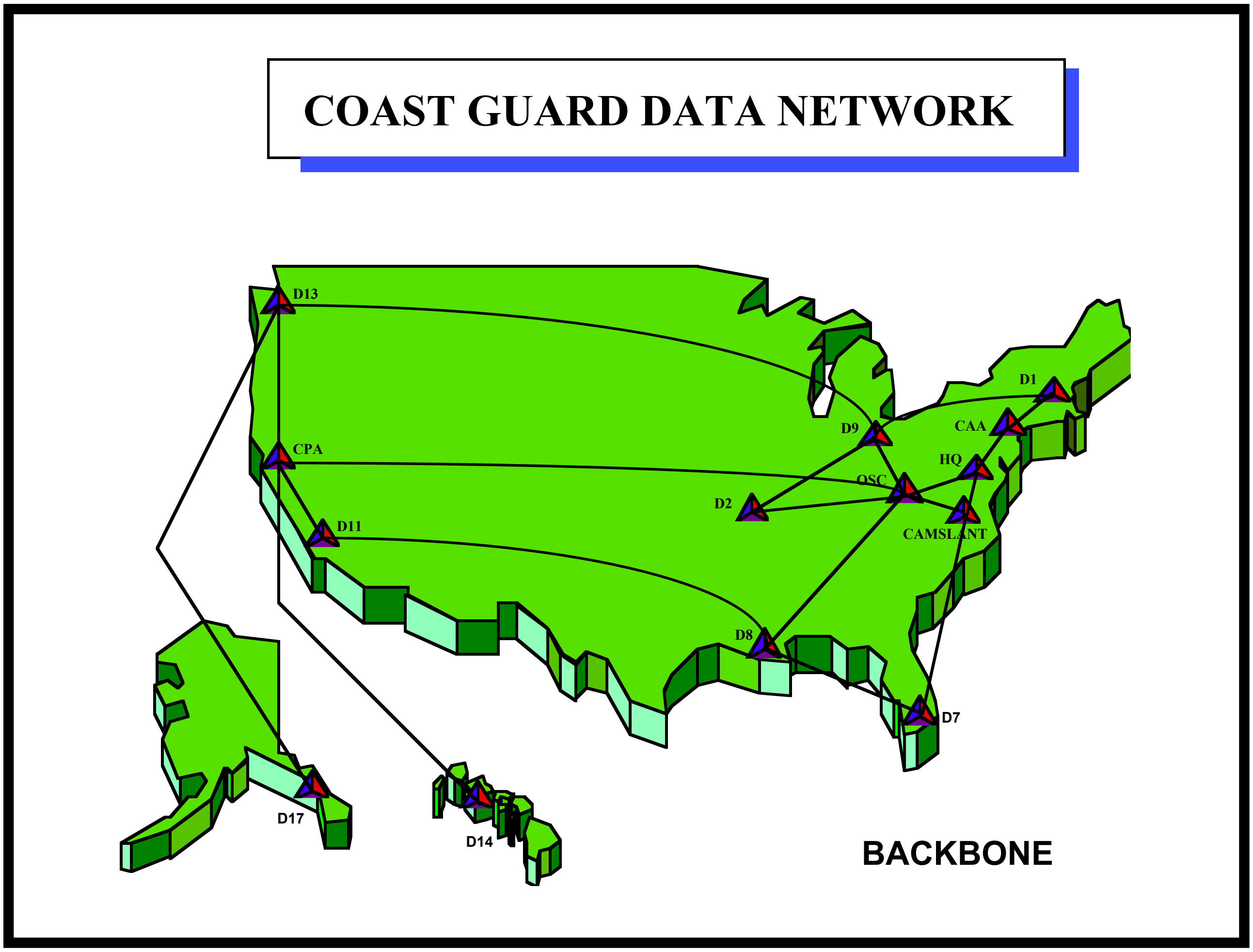


Figure 4-1: CGDN Backbone Network

Secondary nodes are installed at Groups, Marine Safety Offices (MSOs), Air Stations, Communication Stations (COMMSTAs), and other selected units. The nodes at these sites are connected to the backbone through one of the major nodes, typically the district to which they are assigned. Transmissions between secondary and primary nodes may be either 56 or 9.6 kbps, depending on traffic volume.

Although most CGDN locations are provided access via dedicated circuits, traffic volume at some units does not justify this cost. At these units, access to the CGDN is made available via a dial-up telephone line through the local commercial carrier. This type of connectivity is frequently referred to as “virtual” access. The singular disadvantage of virtual access is that traffic for all users, at these locations, must be held in the system until the users dial into the network. Transmission speed, for this type of connectivity, is 2400 bps.

A network management system is used to monitor the system and locate problems. As implemented, the CGDN normally operates unattended. Support for CGDN equipment is expected to be available until the year 2000.

4.2.2 Asynchronous Transfer Mode (ATM)

ATM is one of several new and emerging networking technologies that addresses today's networking problems. The need for a world-wide, international standard to allow interoperability of information, regardless of the type of information or system, has been the catalyst for ATM development.

Historically, there have been separate methods used for the transmission of information among users on Local Area Networks (LANs), versus users on Wide Area Networks (WANs). This situation has added to the complexity of networking, as user's needs for connectivity expand from the LAN to metropolitan, national, and finally world-wide connectivity. ATM is a method of communication which can be used as the basis for both LAN and WAN technologies. Over time, as ATM continues to be deployed, one standard, seamless ATM network will be formed. Caution should be used, however, in planning an ATM networking solution, since ATM technology is new and not yet standardized across the vendors for WAN implementations. The vendors are working toward those standards and may have them in place before the Coast Guard finalizes its network modernization.

Currently, separate networks are used, in most cases, to carry voice, data and video information. Why? Because each of these traffic types have different characteristics. This, however, is not the case with ATM. Separate networks will not be required. ATM is currently the only standards-based technology which can accommodate the simultaneous transmission of data, voice and video.

ATM networks can be complicated and will likely require significant technician training for Coast Guard implementation. As described above, ATM is a state-of-the-art, emerging standard for communications which will soon be available at speeds up to 622 Mbps, using a layered architecture. This allows multiple services, like voice, data, and video, to be mixed over a single network.

ATM has several key benefits:

- ATM can provide a single network for voice, data, video services;
- Due to its high speed and the integration of traffic types, ATM will enable the creation and expansion of new applications, such as multimedia to the desktop;
- ATM can be transported over twisted pair, coax, and fiber optic cable;
- Embedded networks will be able to gain the benefits of ATM incrementally, upgrading portions of the network based on new application requirements and business needs;
- ATM is evolving into a standard technology for local, campus/backbone, and public and private wide area services. This uniformity is intended to simplify network management by using the same technology for all levels of the network;
- ATM is scaleable and flexible; and

- ATM coexists with current LAN/WAN technology, and will integrate with numerous existing network technologies at several levels (i.e., Frame Relay, Ethernet, TCP/IP, etc.).

Figure 4-2 shows an example of an integrated voice, data, and video network connecting three remote sites using an ATM technology solution.

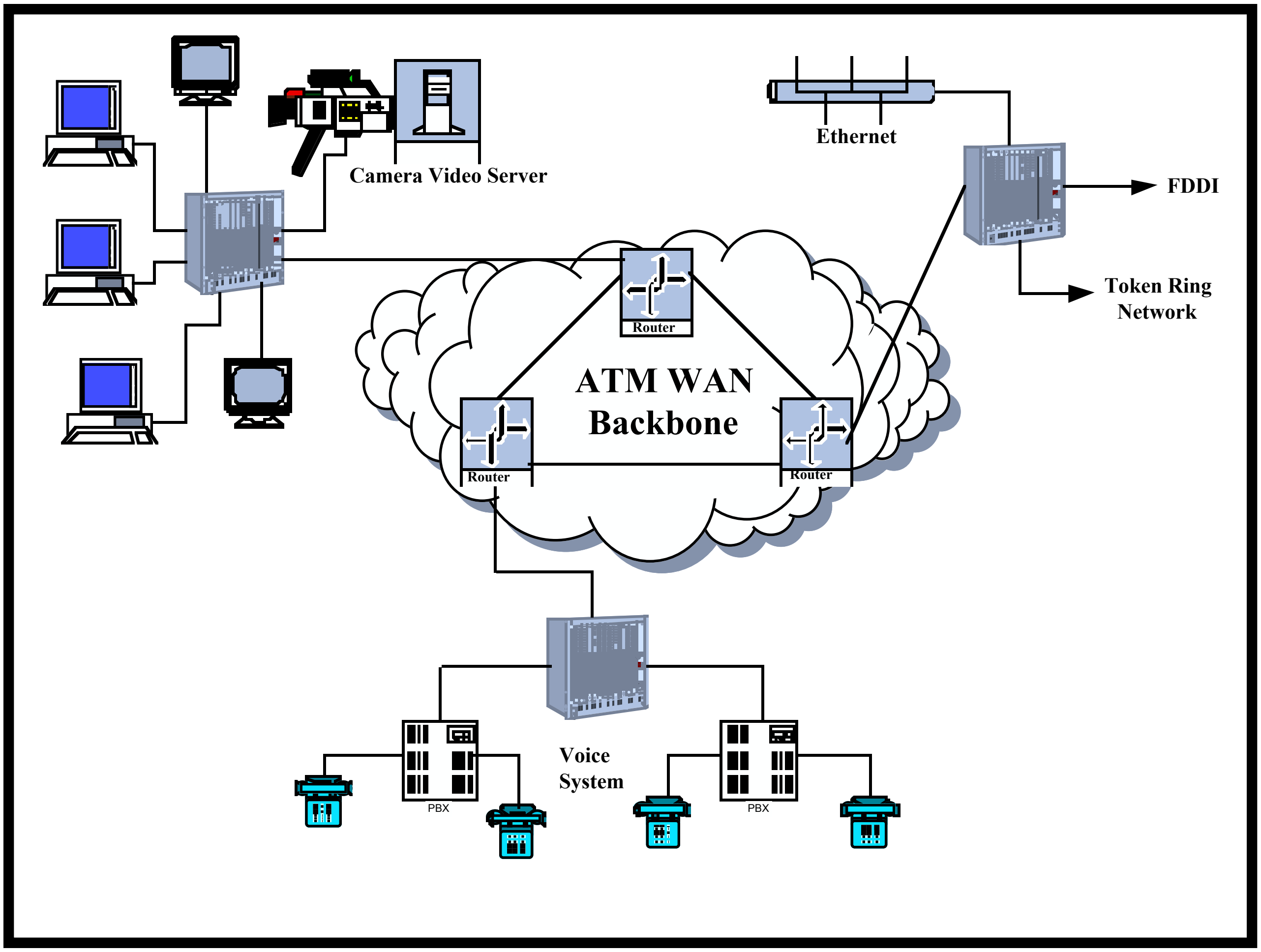


Figure 4-2: Typical ATM Network

Table 4-1, below, identifies the configuration of equipment and services needed to provide ATM communications from the Ethernet LAN at two remote sites (Atlantic and Pacific Area Offices) to a central site (OSC Martinsburg).

Table 4-1: Asynchronous Transfer Mode (ATM)

Item	OSC Martinsburg	Pacific Area	Atlantic Area	Total
Access Speed	T3	T3	T3	
Port Speed	T3	T3	T3	
CIR Speed	2 Mbps	2 Mbps	2 Mbps	
Initial Costs:				
Access/install.	$3,810	$6,620	$3,810	$14,240
Port/install.	$1,500	$1,500	$1,500	$4,500
PVC/install.		$75	$75	$150
Routers - Cisco 4500	$8,100	$8,100	$8,100	$24,300
Sub-total:				**$43,190**
Recurring Costs:				
Port/monthly	$6,000	$6,000	$6,000	$18,000
Access/monthly	$16,000	$7,870	$11,070	$34,940
PVC/monthly		$1,100	$1,100	$2,200
Sub-total:			**Monthly:**	**$55,140**

Point of Contact: Maryland West, AT&T FTS 2000, (202) 776-6481

4.2.3 Frame Relay

Frame Relay is a wide area data communications service designed specifically for bandwidth-intensive and delay-sensitive data applications. It can provide access speeds up to 45 Mbps (T3) while using the principle of shared bandwidth to provide for virtual connections between locations. Frame Relay is a relatively new technology which works over digital and analog lines. This makes Frame Relay very durable. It may be replaced with ATM services in the distant future. However, ATM is fully compatible with Frame Relay and users would not have to change equipment to access the faster ATM circuits.

Figure 4-3, below, shows a typical Frame Relay Network with three remote sites.

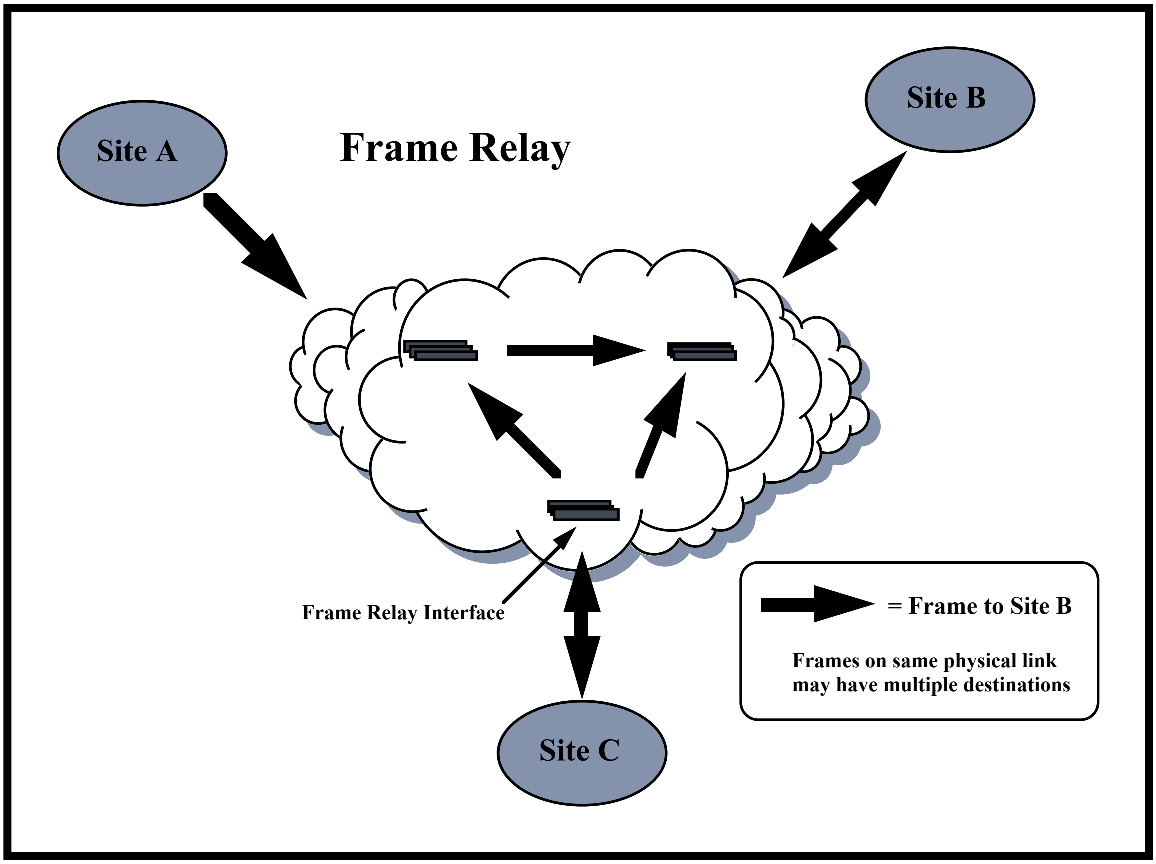


Figure 4-3: Frame Relay Network

Since Frame Relay is a new and growing technology, there should be no concern about this technology becoming obsolete in the near future. Frame Relay services are available nation-wide, making this technology a good choice for all high volume communications. It is very reliable and will meet the Coast Guard's current and future response time and traffic volume requirements.

The virtually noise free and quick connection times of Frame Relay lines cannot be matched. Frame Relay compares well with ISDN services for reliability and far outmatches normal voice grade telephone communications.

For meeting network maintainability and expandability requirements, the long distance carrier, on the FTS2000 contract, maintains the Frame Relay network and users pay for time on the network. Therefore, a call to the long distance provider should be all that is needed to fix Frame Relay line problems.

The Committed Information Rate (CIR) and Peak Bandwidth are both flexible and expandable from a low bandwidth of 32 kbps to bandwidths as high as 1.544 Mbps. The CIR and Peak Bandwidth will be chosen when buying the Frame Relay service. At a future date, when users need a higher CIR or Peak Bandwidth, they can replace the lower bandwidth with a high bandwidth for either CIR or Peak. Frame Relay offers better performance and expandability than ISDN or regular dedicated circuits.

In addition to data, Frame Relay can also handle voice conversations, fax transmissions, and teleconferencing. It also has a flexible bandwidth for bursty data transmissions. Therefore, users could use a higher bandwidth for bursty data and a lower bandwidth for normal low-volume usage, and only pay for the higher bandwidth when they need it.

The FTS2000 contract offers a Frame Relay network management feature that can be used to monitor the entire network from a central site and also account for traffic by user. This system would quickly alert network managers to any problems with the network.

A Frame Relay virtual circuit is similar to a typical telephone cable which may contain multiple pairs of wires, one for each individual conversation. In Frame Relay, a single physical interface may contain several individual conversations. However, unlike a typical telephone call, multiple logical channels exist in a single physical circuit. Also, unlike a typical telephone call, no network resources are used when there is "silence" on the line. This is the real power of Frame Relay.

Frame Relay scales itself based on user need. Some of the major INTERNET service providers are deploying high-speed Frame Relay backbones to guarantee customers' network availability. Because of increasing demands for more bandwidth, service providers are choosing Frame Relay to provide high performance, cost-effective solutions to their customers.

High-speed Frame Relay provides a viable alternative to end users who are not ready to commit to ATM services. With the ability to reach T3 speeds (equal to 28 T1s or 44.736 Mbps), the investment in Frame Relay equipment and services can be maximized for years to come.

Frame Relay represents the alternative requiring the least amount of training for Coast Guard personnel. Since it is an evolution of the X.25 protocol, the Coast Guard technicians should be familiar with most of the language and procedures surrounding Frame Relay.

Table 4-2, on the next page, identifies the configuration of equipment and services needed to provide Frame Relay communications from the Ethernet LAN at two remote sites (Atlantic and Pacific Area Offices) to a central site (OSC Martinsburg).

Table 4-2: Frame Relay Configuration

Item	OSC Martinsburg	Pacific Area	Atlantic Area	Total
Access Speed	T1	T1	T1	
Port Speed	1536	1536	1536	
CIR Speed		512 kbps	512 kbps	
Initial Costs:				
Access/install.	$1,555	$1,555	$1,555	$4,665
PVC/install.		$39	$39	$78
Port/install.	$467	$467	$467	$1,401
Routers - Cisco 4500	$8,100	$8,100	$8,100	$24,300
Sub-total:				**$30,444**
Recurring Costs:				
Access/monthly	$362	$362	$362	$1,086
Port/monthly	$1,831	$1,831	$1,831	$5,493
PVC/monthly		$947	$947	$1,894
Sub-total:			**Monthly:**	**$8,473**

Point of Contact: Maryland West, AT&T FTS 2000, (202) 776-6481

4.2.4 Integrated Services Digital Network (ISDN)

ISDN (also known as Digital Subscriber Line (DSL)) is a totally new concept of what the world's telephone system should be. ISDN's vision is to overcome the deficiencies in today's public switched phone network by providing an international telecommunications standard for transmitting voice, data, and video over digital lines at 64 kbps. They expect to accomplish this by making all transmission circuits end-to-end digital, by adopting a standard out-of-band signaling system, and by bringing significantly more bandwidth to the desktop.

ISDN uses circuit-switched bearer channels (B channels) to carry voice and data, and uses a separate data channel (D channel) for control signals via a packet-switched network. This out-of-band D channel allows for features such as call forwarding and call waiting.

One of the best features of ISDN is the speed of dialing. Instead of 20 seconds for a call to go through on today's analog network, it takes less than a second with ISDN.

The following are examples of available ISDN services:

- Call waiting: If a line is busy and another call comes in, the user knows who is calling. He can then accept, reject, ignore, or transfer the call;
- Citywide Centrex: This provides a number of services, including specialized numbering and dialing plans, and central management of all ISDN terminals, including PBXs, key systems, etc.;

- Credit card calling: Automatic billing of calls into accounts independent of the calling line(s);
- Caller Identification: Provides calling party identification to the called party. Such information may flash across the screen of an ISDN phone or be announced by a synthesized voice. The called party can then accept, reject, or transfer the call. If the called party is not there, then his/her phone will automatically record the incoming call's phone number and allow automatic callbacks when he/she returns or calls in from elsewhere;
- Desktop Videoconferencing: Provides full motion video display of the person you are talking with;
- E-mail: ISDN can carry information to and from unattended phones as long as they are equipped with proper hardware and software;
- INTERNET Access: Provides you with the capability to browse the INTERNET at 128 kbps rather than at 28.8 kbps, which is the fastest speed available with analog modems today.
- Simultaneous Data Calls: Two users can talk and exchange information at the same time.

There are also several new customer services which will significantly broaden the number of useful new services the ISDN telephone network of tomorrow will be able to deliver. One example is the Consultative Committee on International Telegraphy and Telephony (CCITT) Signaling System 7, which removes all phone signaling from the present network onto a separate packet switched data network. This provides enormous economies of bandwidth, and also broadens the information that is generated by a call, or call attempt.

ISDN comes today in two basic flavors:

- Basic Rate Interface (BRI), which provides two 64 kbps B channels and one 16 kbps D channel (2B+D) for a total of 144 kbps. BRI lines, usually designed for the desktop, are provided by the local telephone company, usually for a flat monthly fee. ISDN BRI can give you full motion videoconferencing and ultrafast data communications; and

- Primary Rate Interface (PRI), which provides 23 B channels and one 64 kbps D channel (23B+D), equivalent to a T1. PRI services are designed for telephone switches, computer telephony, and voice processing systems. They are provided by long distance carriers, such as AT&T, over existing phone lines, and are available on the FTS2000 contract.

With ISDN, communications support to large and small Coast Guard units would be provided using ISDN BRI lines, wherever they are available, and by using voice grade FTS2000 dial-up lines from locations where ISDN BRI service is not available. Over a period of time, the dial-up sites could be replaced by BRI services, as ISDN BRI services become available at new locations. Figure 4-4 is an example of an ISDN BRI architecture.

Dial-up services will use the Plain Old Telephone Service (POTS), which is the basic service supplying standard single-line telephones, telephone lines, and access to the public switched network. This would be provided under the FTS2000 contract.

Note: The cost of analog point-to-point services is beginning to climb. Costs are expected to continue to rise as vendors and customers migrate to new standards and digital technology.

The potential complexity of ISDN can result in an equally intensive training problem as discussed in the ATM section.

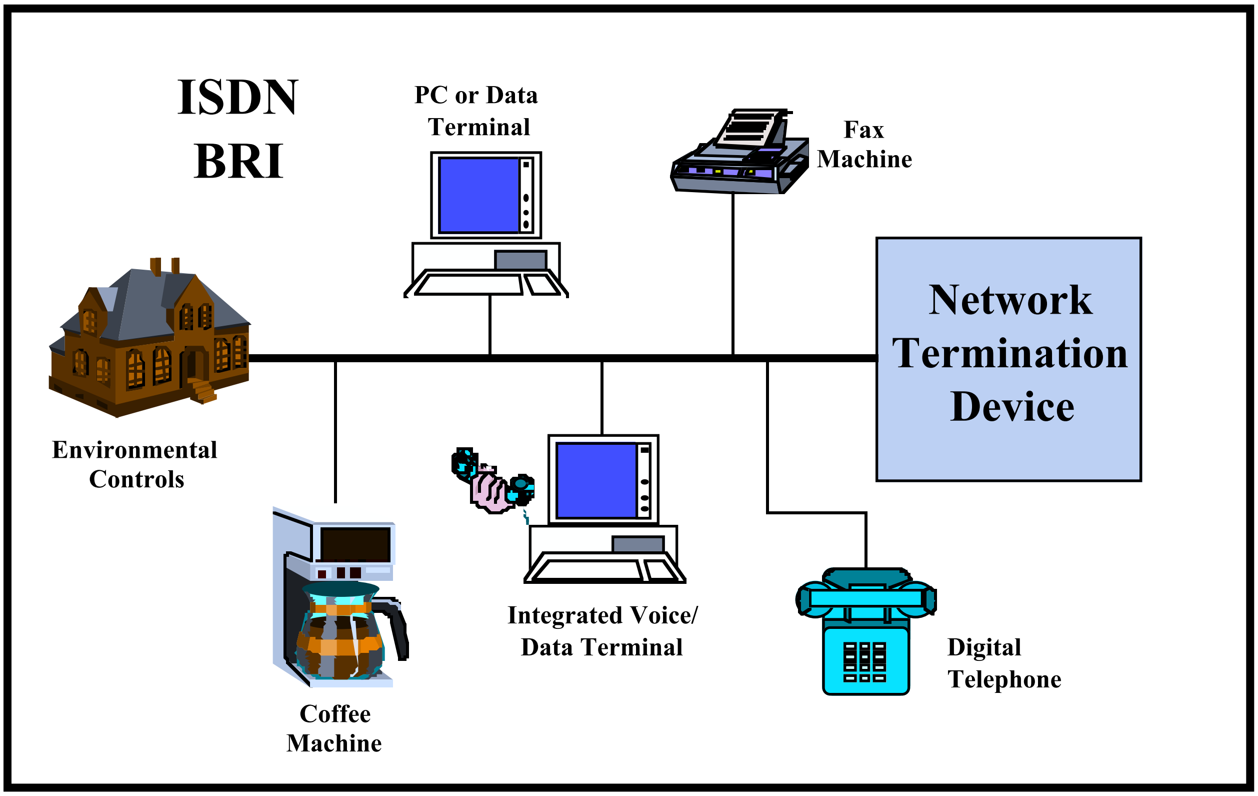


Figure 4-4: ISDN BRI Architecture

Table 4-3, below, identifies the configuration of equipment and services needed to provide ISDN full-time (i.e., 24 hrs./day) communications from the Ethernet LAN at two remote sites (Atlantic and Pacific Area Offices) to a central site (OSC Martinsburg). The requirement may not be a 24 hour virtual circuit, but it is the only way to guarantee a connection like the other WANs provide.

Table 4-3: ISDN Configuration

Item	OSC Martinsburg	Pacific Area	Atlantic Area	Total
Access Speed	T1	T1	T1	
Initial Costs:				
Access/install.	$1,555	$1,555	$1,555	$4,665
Routers - Cisco 4500	$8,100	$8,100	$8,100	$24,300
Sub-total:				**$28,965**
Recurring Costs:				
Access/monthly	$373	$373	$373	$1,119
Monthly Usage		$112,608	$112,608	$225,216
Sub-total:			**Monthly:**	**$226,335**

Point of Contact: Maryland West, AT&T FTS 2000, (202) 776-6481

4.2.5 Point-to-Point Service:

This is the most widely implemented form of wide-area networking. It is available anywhere in the world and is the industry standard. Therefore, all router vendors supply the capability by default. In some cases, it may be more expensive than some other forms of WAN implementation, but it works very well in small scale installations. In large scale installations, it can be difficult to configure and maintain all of the necessary interfaces to effectively and efficiently manage the WAN. This may require significant training for Coast Guard technicians to overcome these configuration problems.

Many units have a need for high-speed transfer of data between large locations. The transfer process may be needed for long time periods each day, as in the case of near-continuous operations involved in financial or scientific applications.

Dedicated T1 service meets this need by providing high-speed digital data transmission at 1.544 Mbps. The service is available 24 hours a day and is priced on a fixed monthly basis. Therefore, it may be more economical to the heavy user who needs the service for long-time periods.

The primary benefits of using dedicated T1 service for this application include:

- The service delivers high-quality performance on an end-to-end basis and is designed for data applications by using digital facilities. The high-speed (1.544 Mbps) allows increased throughput of the data, which saves time and increases productivity.
- The service is cost effective for high-volume users who require availability for long periods of time each month. The rates are not usage-based; therefore, the user has availability 24 hours a day for a fixed monthly rate.
- The service has high reliability.

Dedicated T1 service provides point-to-point (only) transmission at a rate of 1.5 Mbps. This would be enough capacity to transmit the contents of an entire high-density floppy disk in less than 8 seconds. Dedicated T1 is often used to transmit Computer Aided Design (CAD) drawings between locations, to connect LANs, and to tie mainframe computers together, allowing them to share processing power. Figure 4-5 shows a typical point-to-point connection between two remote locations and a central site.

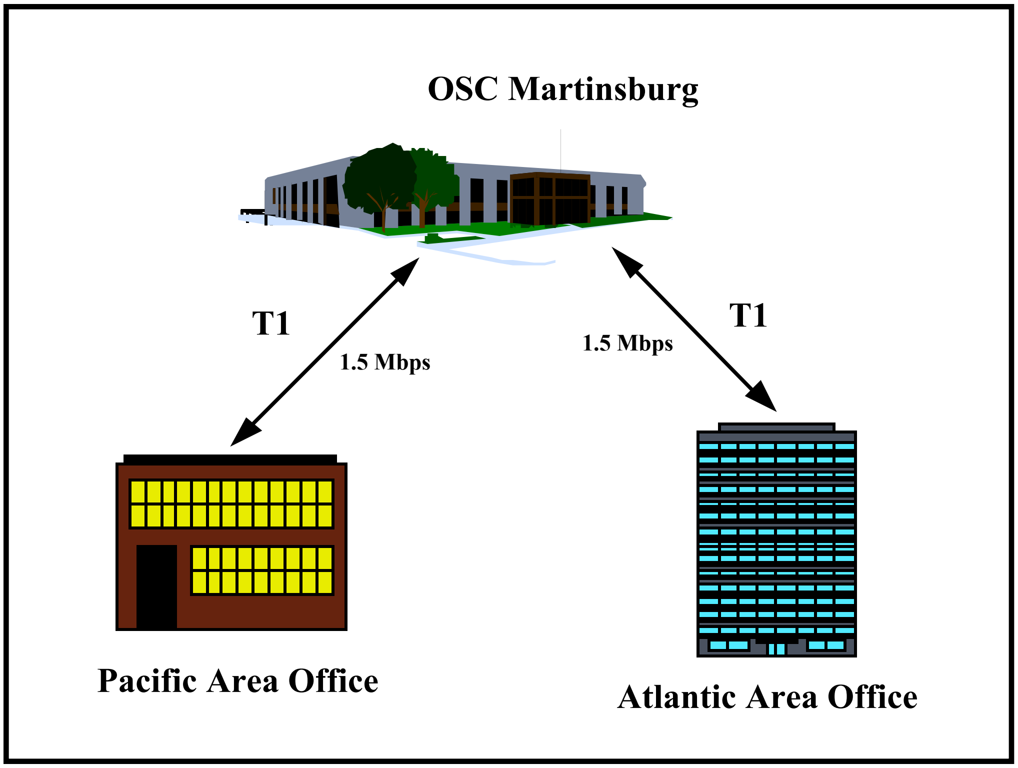


Figure 4-5: Point-to-Point Connection

A user with dedicated 56 kbps service might find that the application requires slightly faster data throughput, but not enough to justify the purchase of a dedicated T1 facility. The solution may be to order fractional T1 service, which affords easy and economical migration to higher data transmission speeds. In many cases, users can double their transmission rates without doubling the circuit price.

Fractional T1 service offers the following benefits for this application:

- The service provides high quality, end-to-end, digital transmission;
- Customer can choose between 11 transmission speeds, providing the right price and performance for the agency's application; and
- Fractional T1 provides data rates ranging from 128 to 768 kbps, in increments of 64 kbps.

Table 4-4 below, identifies the configuration of equipment and services needed to provide point-to-point communications from the Ethernet LAN at two remote sites (Atlantic and Pacific Area Offices) to a central site (OSC Martinsburg).

Table 4-4: Point-to-Point Ethernet (T1 speed)

Item	OSC Martinsburg	Pacific Area	Atlantic Area	Total
Access Speed	T1	T1	T1	
Initial Costs:				
Access/install.		$3,110	$3,110	$6,220
Routers - Cisco 4500	$8,100	$8,100	$8,100	$24,300
Sub-total:				**$30,520**
Recurring Costs:				
Access/monthly		$6,818	$1,734	$8,552
Sub-total:			**Monthly:**	**$8,552**

Point of Contact: Maryland West, AT&T FTS 2000, (202) 776-6481

4.2.6 Very Small Aperture Terminal (VSAT) Networking:

New technology is being developed that will offer high speed access to the INTERNET via a digital satellite system. This technology will provide data services that are several times faster than ISDN and far less expensive. Large files can be transferred at 3 Mbps, with full broadcast channel capacity of 12 Mbps. This system also offers Digital Encryption Standard (DES) compatibility.

Low cost commercial two-way VSAT networking is well into the developmental stage, and maritime mobile VSAT technology has been demonstrated as well. For these reasons, a VSAT network may soon be practically expandable to most Coast Guard units—shore, mobile, and deployable. Also, with planned entrances into this market by RCA, Microsoft, Sony, and Primestar, intense competition should rapidly reduce costs and improve features. This, and a lack of single point failure commonality with the terrestrial networks, should provide major advantages of reliability and survivability either as a back-up or primary system.

Maritime Mobile VSAT technology is now available using commercial off-the-shelf hardware for one-way receipt of data and two-way satellite telephone. Vendors plan to introduce two-way fixed land as well as two-way marine and mobile VSAT data units in 1997. These services provide coverage in the continental U.S. and waters to approximately 200 miles offshore.

Hughes Network Systems now offers a VSAT networking service called DirecPC, which currently provides high speed, one-way, receive-only access to the INTERNET (Figure 4-6).

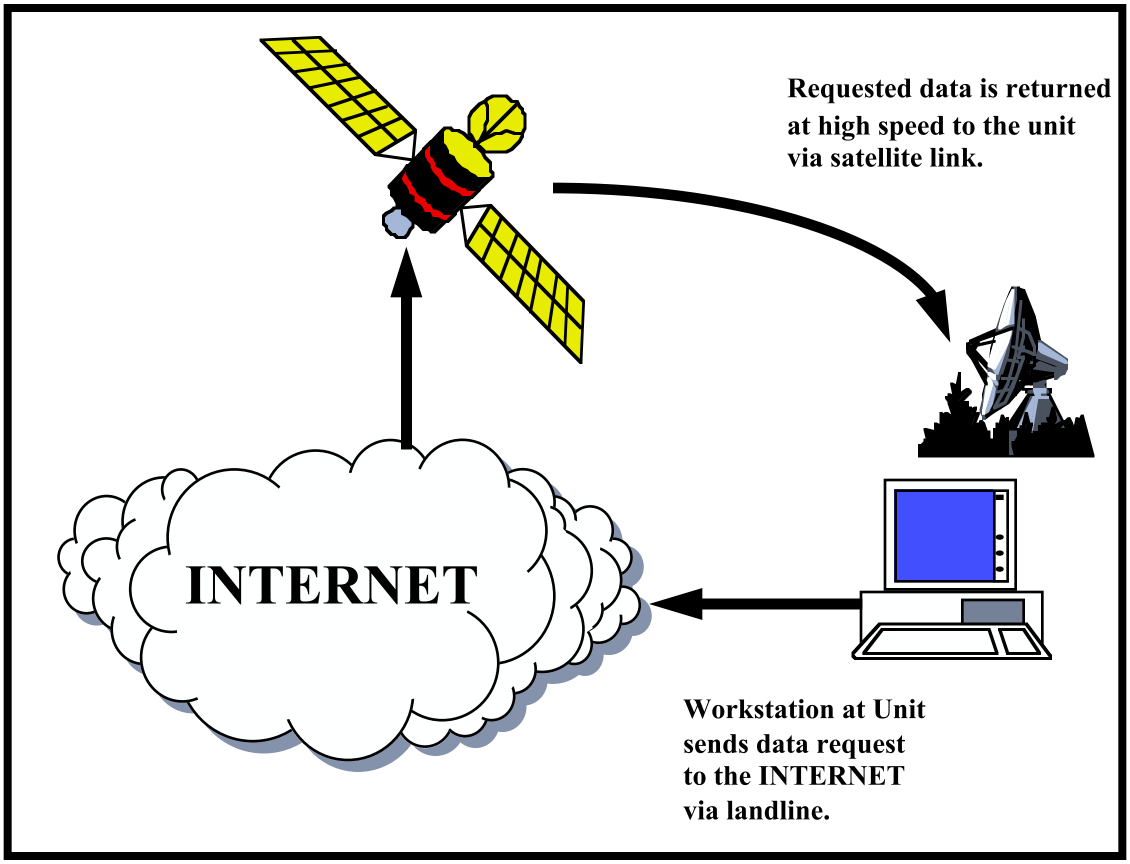


Figure 4-6: DirecPC High Speed INTERNET Service

With Hughes Corporation's DirecPC Digital Package Delivery service, users can have access to one-way broadcast of digital information to an unlimited number of locations. This information includes electronic files, software, documents, and computer-based training. Users can select either a pre-scheduled broadcast or on-demand service.

To transmit information via the DirecPC broadcast, the user sends the broadcast information, along with its corresponding address and schedule, to the service provider's Network Operations Center. From there, it is broadcast via Ku-band satellite to the designated addressees (Figure 4-7).

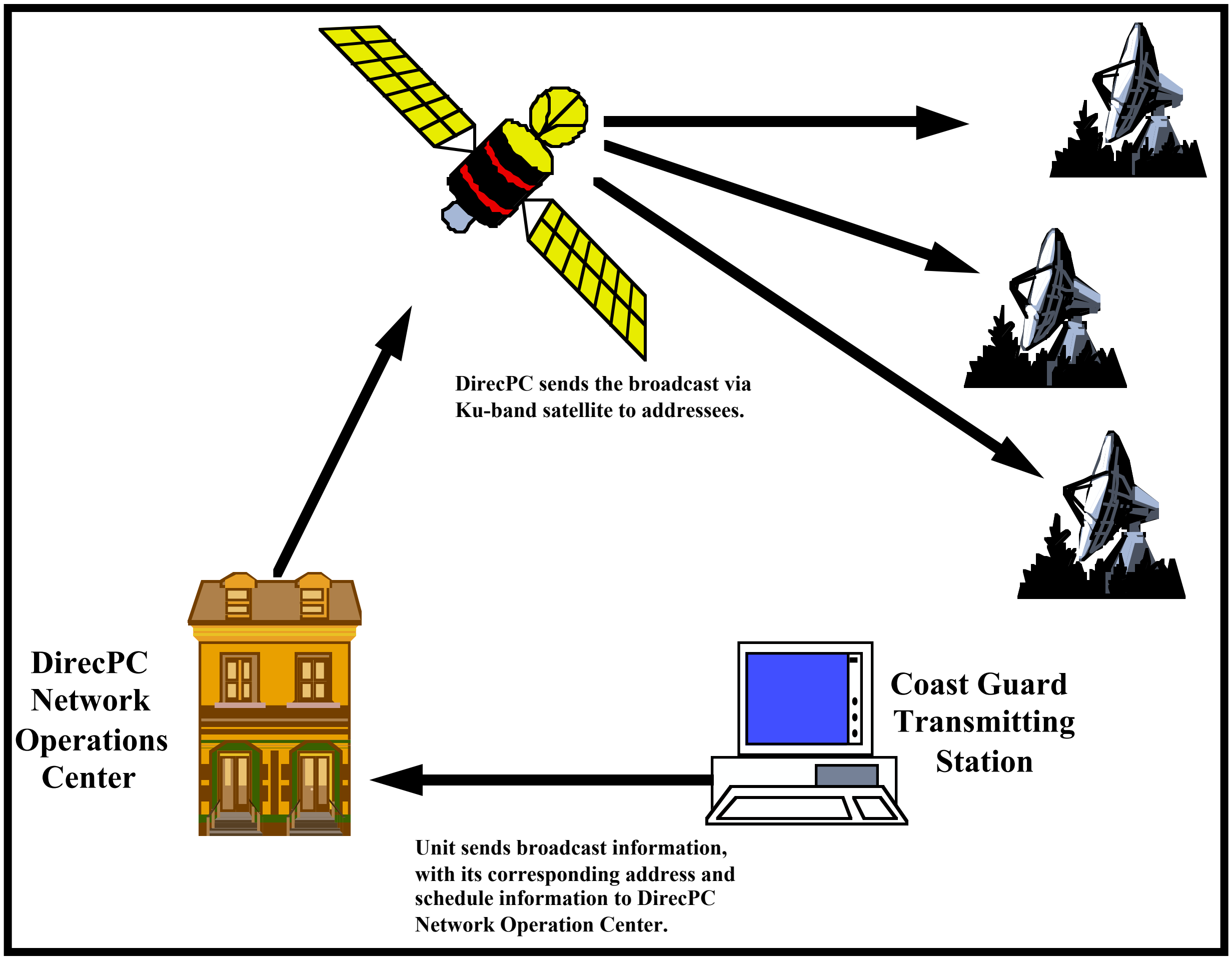


Figure 4-7: DirecPC Broadcast Service

DirecPC provides users desktop video and audio service, and also the capability of transmitting information at high speeds to an unlimited number of sites at a relatively low cost. The service is expandable and the 12Mbps digital channel allows for increased broadcast of video and images.

DirecPC may help the Coast Guard telecommunications system run more smoothly and efficiently by providing a dedicated satellite channel with instantaneous transmission that ensures all locations receive the same information at the same time. Limited initial equipment cost allows for economy and efficient use of transmission capabilities.

In Table 4-5, below, costs are compared between ISDN, DirecPC, and Point-to-Point systems. Since any one or a combination of these systems may be used to provide full-time or back-up services, for the new network, the table shows monthly charges for full-time (24-hour) usage, and for part-time (5% of the time) backup services. ISDN costs decreased significantly, when used as a backup service, since monthly charges are base primarily on per minute usage. DirecPC remains the same because flat rate monthly service continues to be the most economical alternative under either scenario. Point-to-Point service remains the same because costs are primarily based on T1 line charges, and dedicated T1 circuits will be required for either full-time or backup systems. (Keep in mind that DirecPC is currently capable of providing INTERNET and INTRANET access services only.)

Table 4-5: DirecPC Cost Comparisons

Service:	ISDN	DirecPC	Pt-to-Pt
Description:	Low-speed digital connection	High speed digital satellite connection	Very high speed digital connection
Initial Cost:	$800	$1,349	$7,000
Monthly Charges:			
Full-time usage	$112,608	$180	$6,818
Backup system only	$5,630	$180	$6,818

POC: info@mail.direcpc.com // 1-800-DIRECPC

All you need to get started is a DirectPC Access Kit (DAK), which includes the satellite antenna, adapter card, and software. Then subscribe to your choice of services—whatever will meet your operational or administrative needs. These services include a wide range of information services and data delivery options to meet voice, data, and video requirements. DirecPC also provides the capability of protecting sensitive data during transmission by using DES encryption.

Until this technology is further developed, it may not offer the Coast Guard a viable, full-service data networking solution. However, this type of system may prove to be useful in emergencies and disasters, and also by at-sea mobile units for obtaining operational message traffic and other critical information from VSAT broadcast services. These services may provide significant cost reductions when compared with INMARSAT services, currently used where available. Since this technology is designed to be easy to install and operate, technician and operator training requirements are considered to be minimal.

4.2.7 Defense Message System

The Defense Message System (DMS) provides secure, accountable, and reliable messaging services, fully integrated with a global DoD directory service, based on Joint Staff validated requirements. It has a robust set of services that will work writer-to-reader, desktop-to desktop in DoD and externally.

With these capabilities, the Coast Guard will be able to access global directories from anywhere in the world, complete with addressing, security, and user capabilities information for all the messages sent and received from each desktop.

DMS will be implemented with commercial-off-the-shelf (COTS) products to be based on a set of international, open-system standards that provide full interoperability from writer-to-reader. Additionally, DMS will provide interfaces to and interoperability with other federal agencies, U.S. allies, the commercial sector, and the public. This is being done using a standards-based suite of products that ensure writer-to-reader messaging services and global directory capabilities, without the use of gateways.

Why is the Navy building DMS? With the Automatic Digital Network (AUTODIN), telecommunication centers were essentially using over-the-counter message technology developed in the 1960s to deal with messaging requirements presented by the 1990s.

AUTODIN does have some strong points. It is secure, reliable, and available, which is more than can usually be said for DoD's e-mail system, of which there are 47 different flavors in use. However, AUTODIN is costly, staff intensive, incapable of passing binary files, and results in the infamous writer-to-reader message delivery delays. After all, the fastest inter-switch trunk operates at 4800 bps! In today's environment, that is very slow.

Today's legacy, although proprietary, e-mail capabilities offer a rich set of services for use within DoD's local enclave. However, they lose those services when the message is transferred through one of the many DoD Simple Mail Transfer Protocol (SMTP) gateways, across the SMTP backbone, then through another gateway into another proprietary e-mail enclave. This causes problems. Those gateways aren't secure, and they are infamous for addressing problems.

While SMTP e-mail is more flexible and easier to use than AUTODIN, it suffers from a lack of enterprise-wide management, integrity, accountability, security features, and standardization of service. In short, neither system provides optimum capabilities.

These problems, coupled with the problems of AUTODIN, are legacies of old technology. The loss of service and costs inherent in these legacies can't be tolerated in today's environment.

As a solution to these problems, DMS takes organizational messaging and individual e-mail messaging and brings them together in a single system based on a single set of standards. This allows different brands of standard-based products to interoperate with each other without the use of gateways.

DMS is divided into two major pieces: the infrastructure piece and end-user piece. This was done for two reasons. One was from a management perspective, ensuring DISA could manage the infrastructure, and also to be sure the local managers can maintain their piece. The infrastructure piece will be paid for by DISA, put on the ground by DISA, and managed and maintained on DoD computers. From a user perspective, the components will be provided by the services and agencies and will be managed on the desktop by the local commander. The DMS infrastructure consists of the following:

- X.400 Message Transfer Agents connecting all DMS User Agents;
- Directory System Agents (DSAs) containing distributed directory information for the entire DoD;
- Mail List Agents (MLAs) performing multiple deliveries for messages addressed to a single collective address;

- Multifunction Interpreters (MFIs) providing protocol translation for interoperability during transition, and with non-DMS systems after transition; and
- DMS Management and Control function designed to keep the infrastructure up and running.

Here's the DMS solution. To ensure interoperability, as well as retention of services from writer-to-reader, the elimination of gateways, by the inclusion of a common message standard for both organization and individual messages, is required. The absence of gateways will improve interoperability by providing a single addressing structure, allowing writer-to-reader security, ensuring a consistent set of services, and eliminating gateway-derived delivery difficulties. X.400 was designed with this sort of interoperability in mind.

The only protocol translations required will be those needed to communicate between DMS compliant users and users not on similar systems. These users include AUTODIN during the transition to DMS (for organizational messaging only), other (non-DMS compliant) X.400 users, and those using SMTP/MIME as the common backbone for connecting enclaves of proprietary messaging components (i.e., INTERNET users).

It is very important to understand that with secure, reliable DMS, there will be no more DD-173s, no more walking to the telecommunication centers, no more paper distribution, and paper database directories. That's over.

Figure 4-8, below, represents the DMS target architecture and depicts the DMS objective system. It is a representative sample of the DMS implemented in the year 2000 timeframe and will serve users while at home-base, traveling, or tactically deployed. Traveling users may dial-in to DMS through authenticated DISN access points. Deployed users will interface to the same messaging system as those on shore.

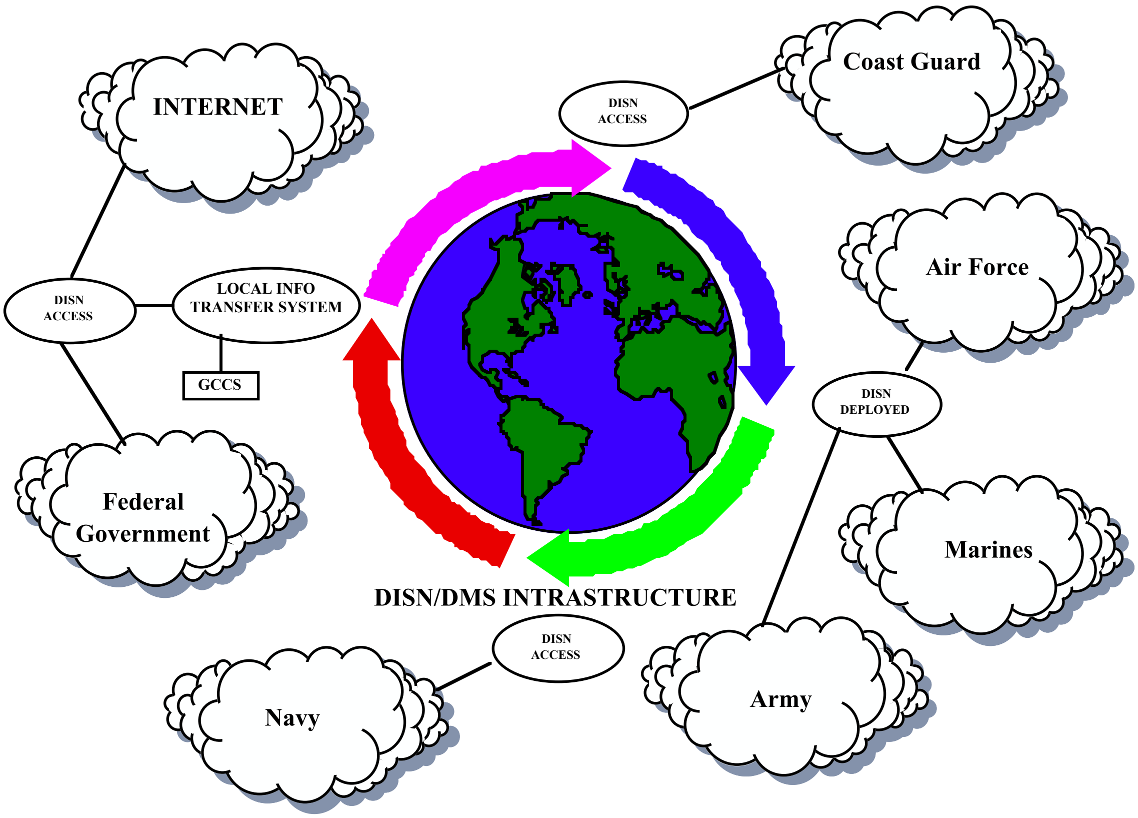


Figure 4-8: DMS Objective System

DMS Training: DMS training is being developed to provide a continuation of defense message handling and capability through the use of current trained and experienced personnel. DMS training courses will be conducted using a variety of training methods at locations world-wide. Training courses may be taught by contractor personnel or previously trained Government personnel. Training courses may be held at contractor resident training locations or conducted at DoD sites by mobile training teams. The courses may also be available through interactive courseware and video tape media.

The courses outlined below, available through DISA's contract with LORAL Federal Systems, are designed to be taught at either a Government facility or contractor site, for individual users, or by contractor personnel/Government instructors:

- Basic User Training Course (User Agent Course);
- Operating System Administrator (OSA) Course;
- Message Handling System (MHS) System Administrator Course;
- Directory System Administrator (DSA) Course; and
- Management Workstation Product (MWS) Course.

Network Security: As the number of users grows, the need to provide Network System Security (NSS) products increases. Today's information system communications environment consists primarily of dedicated system high networks—networks that are classified at the highest level of data they carry.

Communications between these different system high networks is limited. The goal with the deployment of NSS products is to eliminate dedicated communications backbones by collapsing them onto one unclassified backbone which will then carry data of different classification levels. Deployment of NSS components is intended to provide information system users with a wide range of Information Systems Security (INFOSEC) capabilities within an acceptable risk environment. This deployment philosophy is based on the principle of risk management instead of risk avoidance.

The basic NSS components are FORTEZZA cryptographic cards, Certificate Authority Workstations (CAWs), firewalls (discussed later on in this section), Standard Mail Guard (SMG)/Secure Network Server (SNS), and In-Line Network Encryptors (INEs). Deployment of a combination of NSS products provides users with a multi-level security capability. NSS products provide the security features which will be implemented as part of DMS deployment.

Firewall: A firewall is a collection of hardware and software components that is placed between two networks to provide security services. All traffic that passes between the networks must go through the firewall. The security services, provided by a firewall, include access control, user authentication, and logging/auditing. Firewalls can also be used to restrict network services/applications. These network services/applications may include HyperText Transfer Protocol (HTTP), File Transfer Protocol (FTP), and SMTP. The local security policy, in place at the site, is the governing factor which defines what traffic will be allowed to pass through the firewall.

Some of the benefits of having a firewall are that it centralizes security management, allows for auditing, and it can be hosted on standard workstation platforms. FORTEZZA is currently being implemented within firewalls to provide stronger authentication mechanisms. A firewall, in itself, should not be viewed as a total security solution for networks. A combination of other NSS components should also be installed to reduce network vulnerabilities.

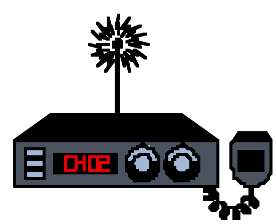
DMS will be explored in greater detail for the Interoperability Section later in this chapter

4.3 Mobile Communications

The wireless communications market is entering a period of long and steady growth. The technologies are yielding faster performance, there are more users than ever, and there are more available products. Many information technologists are beginning to augment their current LANs and WANs with some form of wireless data communications. This Section will focus on mobile communications technologies, and identify several alternatives which may meet all, or some portion, of the Coast Guard's current and future communications requirements.

Wireless networks offer service to mobile assets and portable users. Wireless networks are usually the sole means for moveable platforms to communicate off-platform when on the move. Several wireless networking alternatives, including High Frequency (HF) and Satellite Communications (SATCOM) point-to-point communication technologies and services, are discussed below. A detailed analysis of three selected network alternatives will be conducted in Chapter 5.

4.3.1 Spread-Spectrum Packet Radio



In 1985, the Federal Communications Commission (FCC) allocated three frequency bands for a radio transmission technique known as Spread Spectrum communications, originally developed by the military. This transmission technique has much greater immunity to interference and noise compared to conventional radio transmission techniques. In addition, an increasing number of users can use the same frequency (similar to cellular). These rules are designed to drive usage towards local data communications.

The conventional radio signal is referred to as narrow-band, which means that it contains all of its power in a very narrow portion of the radio frequency bandwidth. Due to the relatively small portion of the radio band that an individual radio transmission occupies, the FCC has traditionally favored these conventional radios. However, as a result of the very narrow frequency, these radios are prone to interference (a single interfering signal at or near their frequency can easily render the radio inoperable).

Spread Spectrum is a technique that takes a narrow-band signal and spreads it over a broader portion of the radio frequency band. This has the operational advantage of being resistant to interference. However, due to unfounded concerns over the increased frequency space it occupies, the FCC, until recently, did not permit commercial use of the technology.

In performing Spread Spectrum, the transmitter takes the input data and spreads it in a predefined method. Each receiver must understand this predefined method and despread the signal before the data can be interpreted.

There are two basic methods to performing the spreading: (1) Frequency Hopping, and (2) Direct Sequencing. Frequency hopping spreads its signals by "hopping" the narrow-band signal as a function of time. Direct sequencing spreads its signal by expanding the signal over a broad portion of the radio band.

The FCC allows the use of Spread Spectrum technology in three radio bands, 902-928 MHz, 2400-2483.5 MHz and 5752.5-5850 MHz for transmission under 1 Watt of power. This power limit prevents interference within the band over long distances.

Spread spectrum is highly secure. Would-be eavesdroppers hear only unintelligible blips. Attempts to jam the signal succeed only at knocking out a few small bits of it. So effective is the concept that it is now the principal antijamming device in the U.S. Government's MILSTAR defense communications satellite system.

- **Advantages to Spread Spectrum:**

  - No FCC Site License - The FCC will grant a one time license on the radio product. After that license is granted, the product can be sold anywhere in the U.S.
  - Interference Immunity - Spread Spectrum radios are inherently more noise immune than conventional radios. Thus they will operate with higher efficiency than conventional technology.
  - Multi-Channel - Conventional radios operate on a specific frequency controlled by a matched crystal oscillator. The specific frequency is allocated as a part of the FCC site license, and the equipment must remain on that frequency (except for very low power devices, such as cordless phones).
  - Spread Spectrum data radios offer the opportunity to have multiple channels which can be dynamically changed through software. This allows for many applications, such as repeaters, redundant base station, and overlapping antenna cells.

A major point in choosing Spread Spectrum is the fact that you can implement a Code Division Multiple Access (CDMA) system which is a way of allowing more users to communicate at the same time in the same frequency band. Each user has its own code, therefore a message can be recovered knowing the right code. CDMA is able to "prioritize" signals based on the length of the code assigned. As the channel gets full, signals with shorter code lengths drop out first due to noise of other signals. CDMA is often considered the technology of choice because of its capacity and voice quality. The major advantage of CDMA is that it allows the provider to operate both fixed and mobile systems using the same infrastructure and platform. Currently, the high cost of CDMA makes it less attractive, and a large channel allocation is required. However, a rapid decline in equipment costs is expected, as cellular and other applications use drives up CDMA modem production.

The system is a short distance wireless communications system, whose application can be voice transmission, modem application, remote sensing/controlling, etc. The idea is having a point-to-point (non-cellular) system which does not need a complicated infrastructure. This system may serve as a reliable link for short-haul disaster communications and a critical component of the Transportable Communications Central (TCC) communications suite.

Table 4-6: Spread Spectrum Pros and Cons

PROS	CONS
Transmission Security	Limited to 1 Watt power
No FCC site license required.	Limited number of frequencies available.
Higher efficiency than conventional technology	Susceptable to Far-Near effect
Interference resistant	
Multi-channel capabilities	

(Note: The "Far-Near" effect is a problem which is caused by the fact that transmitters are received with non-equal powers. If, for example, there are three users in a specific cellular area, user-1 is transmitting traffic to user-2. It is possible that user-3 will interfere with User-2's reception if User-3 has more power and is closer to User-2 than User-1. In a cellular approach, this is addressed with the concept of Power Control. Frequency Hopping is another method of combating the Near-Far effect.) (Ref: http://www.eng.usf.edu)

Below is one example of how Spread-Spectrum technology is currently being used as a wireless network to route packets to and from mobile users.

- ***<u>Ricochet Wireless Network:</u>*** A good example of Spread-Spectrum technology is the Ricochet Wireless Network, which is a packet radio network operating in the unlicensed 902-928 MHz band. The technology requires a subscriber device and pole top repeating radios, Wired Access Points (WAPs), and Network Interconnection Facilities. Applications that operate using a wired modem for communications can become wirelessly enabled by replacing the phone modem with a Ricochet wireless digital modem. The modem is portable, weighing 13 ounces, and attaches to the serial port of any computer.

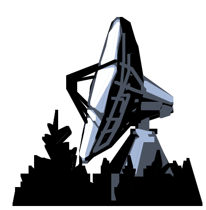
Repeaters are typically mounted on street light pole tops. The wireless mesh serves to route packets to and from mobile users. Interspersed amongst the mesh radios are WAPs. These are locations where the wireless packets are routed onto Ricochet's wired backbone. Once on the wire, the packets can be delivered via several means, including INTERNET.

Frequency hopping, dynamic routing, and password and authentication techniques make detection and interception of information extremely difficult.

The Ricochet LAN Gateway is installed on a user premises between a LAN and the Ricochet "cloud". Ricochet users can easily dial into the gateway wirelessly, providing they have been given the proper access privileges. Industry-standard encryption and authentication schemes ensure privacy for both the information transmitted and the access to the network itself. Depending on the Gateway's configuration and the wireline connection to the Gateway, it can support 100-1000 users. The Gateway provides "persistent connections" rather than the typical "continuous reconnections" required in a modem bank. For users, this means that, unlike traditional telephone modem banks, users will not get a busy signal when the number of users exceeds a certain number. Instead, the Gateway will provide equivalent performance for all users on the network, although the highest level of performance may not always be attained for individual users during peak usage periods.

Ricochet modems can be leased for $10 per month or purchased for around $200. The basic monthly service charge is $30, which includes unlimited wireless INTERNET access and a Post Office Protocol (POP) e-mail account. Telephone modem access capability can be added for another $5 per month, which gives you the ability to call into services accessible only through telephone numbers. Dial-in service, to allow you to retrieve mail from outside the Ricochet service area, is $10 per month. (Ref: http://www.metricom.com/ricochet)

4.3.2 Satellite Communications



Several commercial and military satellite systems are capable of meeting the Coast Guard's ever increasing record message and tactical communications requirements. The desire to "move data" more rapidly and with greater reliability drives the need to seek new and improved technology. This sub-section will discuss several currently available satellite communications technologies that may effectively meet the Coast Guard's current and future telecommunications requirements. Some of these technologies, however, are relatively new and have not yet matured into fully developed systems.

4.3.2.1 Low Earth Orbit Satellites (LEOS)

There are several satellite systems in various stages of development that may meet the Coast Guard's voice, data, and video communications requirements. These systems will greatly expand the available coverage areas by offering service everywhere on earth, including the polar regions where current satellite services cannot reach. LEOS will also eliminate the requirement for stabilized dish antennas for mobile platforms.

LEOS provide services as diverse as worldwide paging with acknowledgment, worldwide handheld telephone service, and vehicle tracking where the mobile unit sends up a continuous stream of information about its whereabouts. The primary advantage of LEOS is that the transmitting terminal does not have to be very powerful. The reason for this is that LEOS are so much closer to the earth than traditional geostationary satellites, which are satellites placed in a geosynchronous orbit 22,300 miles directly over the earth's equator. However, to maintain communications, you must always have "several" of these satellites above you.

There are several proposed LEO systems under development. These include Iridium, Globalstar, Odyssey, INMARSAT-P, Spaceway, and Teledesic. Because of big industry backing, Iridium and Globalstar are the two systems most likely to succeed.

- **Iridium**: Iridium is Motorola's satellite project to "bring personal communications to every square inch of the Earth." Although the project is still in the research and development stage, Motorola intends to provide global personal satellite based communications via handheld terminals by the year 1998. For the first time, anyone, anywhere, at any time can communicate via voice, data, or video. Motorola estimates the service costing approximately $3.00 per minute.

  The idea is that everyone will carry an Iridium handset no larger than today's cellular phone, and will be able to talk directly from their phone to the satellite (one of 66 satellites which will fly in eleven nearly polar orbits (tilted 86 degrees) 420 miles out) and then down to the ground or to a satellite dish, through landlines to the phone of the person being called. The benefit is that the system knows who you are and where you are the moment you turn on your phone. This feature may have several other uses in the maritime community, especially in the areas of SAR and law enforcement operations.

  The Iridium satellites will not only talk to handsets and ground stations, they will also talk to each other, forming a network aloft, passing on conversations, and handing them off when they drift out of range. Because of these satellite-to-satellite crosslinks, the Iridium system will be able to handle calls to other Iridium phones without reference to any ground stations at all, once the link is established.

Iridium's primary features include:

- A constellation of 66 satellites in a low Earth orbit of 483nm;
- Satellites travel 15,000 mph, circling the earth once every 100 mins.;
- 11 operational satellites and one spare will populate each of 6 orbital planes;
- 48 spot beams within each satellite's footprint;
- A 16db signal power margin, enabling customers to use the handset inside a car;
- A 5 to 7 year on-orbit lifetime;
- Both frequency and time division multiplexing;
- Digital voice at 4.8kbps, and data at 2.4kbps;
- 15 to 20 ground gateways that link the satellite system with the terrestrial public switch telephone network; and
- A master control center in the U.S. and a backup facility in Italy.

(C4I Technology Assessment, Pg. 110-111)

- **Globalstar:** A new communications tool—the hand-held satellite telephone—will be available before the turn of the century. At about the same time, affordable, basic telephony—through fixed-site satellite telephones—will be available for the first time. Globalstar will usher in both.

  Globalstar is a LEO satellite-based digital telecommunications system that will offer wireless telephone and other telecommunications services worldwide beginning in 1998. Globalstar will provide low-cost, high quality telephony and other digital telecommunications services, such as data transmission, paging, facsimile, and position location to areas currently underserved or not served by existing wireline and cellular telecommunications systems.

  Globalstar service will be delivered through a 48-satellite LEO constellation that will provide wireless telephone service in virtually every populated area of the world. Globalstar will begin launching satellites in the second half of 1997 and will commence initial commercial operations via a 24-satellite constellation in 1998.

  Full 48-satellite coverage is projected for the first half of 1999. Users will make or receive calls using hand-held or vehicle-mounted terminals, similar to today's cellular telephones. Because Globalstar will be fully integrated with existing fixed and cellular telephone networks, Globalstar's dual-mode handsets will be able to switch from conventional cellular telephony to satellite telephony, as required.

In remote areas, with little or no existing wireline telephony, users will make or receive calls through fixed-site telephones, similar either to phone booths or ordinary wireline telephones. Each subscriber terminal will communicate through a satellite to a local Globalstar service provider's interconnection point (a gateway) which will in turn connect into existing telecommunications networks.

Hand-held and mobile services will be provided to areas where cellular coverage is poor or non-existent. Users will include fishing boats, yachts, and other small craft and short-haul commercial and general aviation aircraft.

Telecommunications service providers AirTouch, Dacom, France Telecom, Elsag Bailey, and Vodafone will provide on-the-ground marketing and telephony expertise to Globalstar. Telecommunications equipment and aerospace systems manufacturers have contracted to design, build, and deploy the Globalstar system. Loral Corporation has overall management responsibility for the Globalstar system, its design, construction, deployment, and operations. Loral will build Globalstar's satellite operations control centers (SOCCs) and portions of its ground operations control centers (GOCCs).

Qualcomm, Inc., using its CDMA technology, will design and manufacture subscriber terminals and gateways, and will have primary responsibility for the design and manufacture of the GOCCs.

To achieve low cost, reduce technological risk, and accelerate deployment of the Globalstar system, Globalstar's system architecture uses small satellites incorporating a well established repeater design that acts essentially as a simple "bent pipe," relaying signals received directly to the ground.

(POC: Globalstar Limited: (408) 473-5872)

4.3.2.2 American Mobile Satellite Corporation (AMSC)

AMSC provides satellite-based mobile voice and data communications services throughout the United States. Their satellite telephone service provides a variety of land, maritime, and aeronautical based applications. Pleasure boaters, commercial mariners, and government can subscribe to satellite service to gain access to ubiquitous mobile telephone services hundreds of miles off U.S. shores. However, ships at sea will need the stabilized dish antenna because they will be operating on the fringe areas of the satellite's effective footprint. This service is available at a fraction of the cost of satellite telephone services offered today by other companies.

AMSC terminals are small and inexpensive, and their charge per minute is reasonable. This will allow installations on most Coast Guard vessels, and AMSC covers the vast majority of the areas where the Coast Guard operates (i.e., virtually all of North America, the Caribbean, and all U.S. coastal waters). Voice, data, and FAX will be available, and a Global Positioning System (GPS) chip will allow location to be displayed on the handset. Differential GPS corrections are available over the satellite. AMSC provides fixed site support for remote locations and for alternate routing for high priority circuits where landlines may be vulnerable to terrestrial disasters.

AMSC will provide normal telephone service, from your mobile satellite unit, at rates a fraction of those currently available elsewhere. With AMSC, there are no additional long distance charges for domestic calls.

STU-III, as well as other NSA approved secure data and voice systems will be available. This will allow alternatives for Navy Fleet Satellite Communications (FLTSATCOM), High Frequency Data Link (HFDL), and other systems where a secure capability is necessary.

AMSC also has a low cost aeronautical terminal. The Coast Guard is currently testing some of these terminals on HH-60 helicopters. They will provide an alternative for long range aeronautical communications.

The AMSC system allows for "talk groups" to be established. These may be used for messages or party line applications. For example, all cutters in the Caribbean could constitute one talk group, oil spill responders another, etc. All maritime users in an area could be in a talk group for facilitating maritime safety and receiving marine information broadcasts. Each telephone may belong to a maximum of 15 different talk groups, and each talk group may have as many as 10,000 phones.

Talk groups may be reconfigured over the air, when necessary, without local operator intervention. This will be ideal for establishing interoperability during an emergency when units of several different organizations respond. (If this were implemented in the short term, there would be a giant leap toward interoperability and emergency support.) Many different organizations at the Federal, state, local, and emergency response level are currently using the AMSC system. For the first time, interoperability among all organizations is possible.

Access to the Public Switched Telephone network (PSTN) via the AMSC gateway in Reston, Virginia allows for operations during periods when systems in the area of an emergency are stressed. When hurricanes or earthquakes occur, the AMSC satellite will be above it all and unaffected.

Key attributes of the AMSC satellite system include signal intelligibility and clarity.

Dual mode satellite/cellular radios cost about $3,000; per minute charges for government organizations are $1.20 or less, including terrestrial long distance charges. Talk groups can be established for $100 per month, and practically unlimited users may join them for $70 per month. The $70 per month allows dispatch and significant talk time for users. The Coast Guard could buy 1000 radios for $3 million and operate them in 100 talk groups for about $80,000 per month. Studies have shown that up to 35 users per circuit can be accommodated, so 100 talk groups per 1000 users is conservative.

(POC: Kelly Dressler, AMSC, 10802 Parkridge Blvd. Reston, VA 22091)

4.3.2.3 International Maritime Satellite (Inmarsat)

INMARSAT commenced formal operations on 1 February 1982. The Communications Satellite Corporation (COMSAT), Washington, D.C., is the sole U.S. representative in the INMARSAT Organization, an international organization with 66 member countries that is headquartered in London, UK. COMSAT operates several INMARSAT earth stations in the U.S. and overseas. INMARSAT-A terminals are installed on cutters (210 WMECs and larger), and are used to support both voice and data communications. INMARSAT-C terminals are currently being installed on 110 WPBs and larger cutters, and are capable of data communications only. INMARSAT-A can be used for secure communications, if operated with appropriate cryptographic equipment (i.e., STU-III). Both “A” and “C” terminals are capable of receiving INMARSAT SafetyNet broadcasts, which is a service of the Global Maritime Distress and Safety System (GMDSS) for disseminating maritime safety information to ships on the high seas. Terminals now cost $45,000 each and are as big as file cabinets. Even the newest, briefcase-size model costs $25,000, plus $5.50 per minute of use.

INMARSAT is capable of meeting Coast Guard voice and data requirements, and is generally considered more reliable to use than most of the traditional methods of short, medium, and long-range communications. However, INMARSAT is significantly more costly to operate, with current usage charges of approximately $5.50 per minute. In time, costs are expected to decline as other commercial satellite systems are brought on-line, but under the current budget climate, the Coast Guard has elected to take an active approach to finding a less costly alternative. They are currently testing other satellite systems, in an effort to decrease operating costs and increase the availability of satellite communications.

INMARSAT wants to get into the handheld business, but hasn’t yet decided just how it wants to go about it. The idea has a name—Project 21—and INMARSAT has commissioned studies by a number of major companies for it. With 66 governments on its side, geostationary satellites already in place, and a rapidly growing cash flow from its existing operations, INMARSAT could end up with a global monopoly on satellite phones (in combination with AMSC).

Table 4-7, below, summarizes the characteristics for Iridium, Globalstar, AMSC, and INMARSAT mobile satellite systems.

Table 4-7: Commercial SATCOM Characteristics

Item	Iridium	Globalstar	AMSC	INMARSAT
Satellites	66	48	3	4
Altitude	483.3 miles	750 miles	22,000 miles	22,000 miles
Orbits	Circular 860 tilt	Circular 520 tilt	Geostationary	Geostationary
Uses	Mobile voice, fax, paging	Mobile voice, fax, e-mail	Voice, data, fax, messaging, position location	Voice, data, fax, paging, messaging, position location
Antenna Size	2 meters	1 meter	6.5 meters	1 meter
Spectrum Sharing	No	Yes	Info. Not Avail.	Info. Not Avail.
Modulation Scheme	TDMA	CDMA	Info. Not Avail.	Info. Not Avail.
Intersatellite Links	Yes	No	Info. Not Avail.	Info. Not Avail.
Turnkey	1998	1998	Currently Available	Currently Available
Price per minute	$3.00	$0.30	$1.50	$6.00
Initial Cost	$3,000.00	$700.00	$3,000.00	$25-45,000
Data Speed	4.8kbps	4.8kbps	2.4kbps	2.4kbps
Mode	Satellite	Satellite	Satellite/Cellular	Satellite
Coverage	Global	Global	N. America, U.S. coastal waters, Caribbean, Gulf of Mexico	Global
Voice	Yes	Yes	Yes	Yes
Data	Yes	Yes	Yes	Yes
Handheld	Yes	Yes	Yes	Yes
Mobile	Yes	Yes	Yes	Yes
Fixed Site	Yes	Yes	Yes	Yes

4.3.2.4 Very Small Aperture Terminal (VSAT)

VSAT networks provide rapid and reliable satellite transmission of data, voice, and video between an unlimited number of geographically dispersed sites or from these sites to a central site. Each site is equipped with a VSAT terminal consisting of an antenna, outdoor electronics mounted on the antenna for signal reception/transmission, and indoor electronics for connection to the computer terminal, telephone, and video equipment.

There are three standard VSAT network configurations: (1) Point-to-point, which provides two-way communications between VSATs located at two remote sites. Ideal for point-to-point links over large distances and in hard-to-reach locations, as well as for complete backup of vital network links; (2) Star network, which provides multipoint communications between a hub station located at the central site and VSATs located at an unlimited number of remote sites; and (3) Mesh network, where there are direct communications between VSATs at all sites on the network. Communications are not routed through a hub station; each site on the network “talks” to the other sites with a single satellite hop. Ideal for voice links to hard-to-reach locations, and for data communications among a smaller number of remote sites.

In Section 4.2.6, we described VSAT as a viable shore unit data networking alternative. In the future, a VSAT alternative will apply to mobile units as well. As with shore unit communications, this new and emerging technology will offer cutters high speed access to the INTERNET via a digital satellite system. Large files can be transferred at 3 Mbps, with full broadcast channel capacity of 12 Mbps. This system also offers Digital Encryption Standard (DES) compatibility.

Low cost commercial two-way VSAT networking is well into the developmental stage, and maritime mobile VSAT technology has been demonstrated as well. For these reasons, a VSAT network may soon be expandable to most Coast Guard mobile units. The lack of single point failure commonality with the terrestrial networks, should provide major advantages of reliability and survivability either as a back-up or primary system.

Several service providers offer the technically advanced, user-friendly satellite communications products. These include:

- **AT&T Tridom:** AT&T's Tridom provides VSAT systems to government agencies and communications service providers throughout the world. Using Time Division Multiple Access (TDMA), Tridom connects remotely located computer terminals to the satellite network. The VSAT system includes a network interface unit (NIU), a small antenna and outdoor unit that receives and transmits the satellite signals, and a hub station that contains the central switching and transmission equipment to link all parts of the network.

  A router offers one of the first LAN-capable VSATs that allows users with Ethernet LANs, based on TCP/IP, to interconnect directly with a VSAT-based WAN. The Internet Protocol (IP) router supports communications between any two points on the network. A user can access data located locally, on a remote LAN or in the central host computer. The IP router's diverse capabilities include the ability to route data via terrestrial lines between overloaded sites and the hub, thereby simplifying network management. The IP router's full compatibility and flexibility simplifies operations.

  A voice link module is a compressed digital voice option that allows you to have two-way voice communications on the VSAT networks. The module enables the voice link to share the same outroute and inroute as the data link, thus providing a cost-effective alternative to terrestrial systems and expanding the capability of the VSAT network.

  The Tridom Demand Assigned Multiple Access (DAMA) system represents the state-of-the-art demand-based satellite networking. The DAMA system provides stand-alone connectivity, redundancy, and supports various demand-based connections. With the DAMA system, each terminal can communicate with one or more terminals directly through a single hop link. This intelligent system utilizes sophisticated network control systems and advanced communications technology to provide clear communications access to all subscribers. It is best suited for peer-to-peer voice and data communications in a full-mesh topology where switched circuits are needed and single satellite links are essential.

The new AT&T Global VSAT systems come in two basic models, the Clearlink System 200 and the Clearlink System 400. The two VSAT systems operate with either private or shared hub earth stations, and both models use the Clearlink NIU, which is programmed for either Ku- or C-band transmission.

The smaller system, System 200, is a Ku-band VSAT designed primarily for North American customers with low-volume data traffic who want the flexibility of low-cost satellite data communications. The System 200 uses the smaller 0.95 meter antenna and provides a fixed 64kbps inroute data rate and 256kbps outroute rate.

The versatile System 400 is available in both Ku- and C-band models. The model takes full advantage of the unique software programming capability to provide greater flexibility in network delivery to match changing traffic requirements. Software-programmable variable transmission rates means that the System 400 network can be initially deployed with an inroute data rate of 64kbps and an outroute speed of 128kbps to minimize space segment costs, and then, as traffic demand increases, be re-configured to operate at higher outroute rates of either 256kbps or 512kbps. And, because it is all done by software, the upgrade can be done by the Coast Guard with no additional hardware and no site visits, minimizing the costs. The System 400 can be installed with either a 1.2, 2.4, or 3.5 meter antenna, depending on geography and network configuration.

Both Systems are fully compatible with digital compression and AT&T's new Skynet Global Video Service, which provides compressed digital video satellite transmission. In addition, the System 400 is compatible with the Clearlink Ethernet Router Option (ERO), a plug-in interface card that provides connectivity to 802.3 Ethernet LANs through TCP/IP software. The System 400 also has a compressed digital voice option in the new Clearlink Voice Link Module, which provides cost effective two-way voice communications on VSAT networks.

Prices for the System 200 range from approximately $6,000 to $9,000 per VSAT and the System 400 ranges from approximately $10,000 to $25,000 per VSAT, depending on satellite frequency band and antenna size.

(POC: bob.proffitt@tridom.com)

- **<u>DirecPC:</u>** DirecPC, as discussed in Section 4.1.6, is a data networking alternative that has the potential to meet several Coast Guard communications requirements, including providing voice, data, and video service to mobile units.

  There are three main types of DirecPC service that may be offered: (1) Package Delivery; (2) MultiMedia; and (3) Turbo Internet. Broadly stated, Package Delivery is used when the destination of the information is storage; MultiMedia for "live" broadcast of information; and Turbo INTERNET for INTERNET access and download of files at much higher than dial-up modem rates.

— *Package Delivery:* DirecPC Package Delivery service provides one-way broadcast of digital video, audio, or text based files, such as software, computer-based training, documents, or any other content from a central site to any number of locations. The broadcast can be either scheduled or on demand.

— *MultiMedia:* DirecPC offers one-way packet transmission in a “data-pipe” format for video, audio, or regularly transmitted information that is scheduled and provided as a service. This service is available to a selected group, or all of an information providers locations. The transmission schedule can be selected to meet the needs of the organization, such as:

  - Fixed duration (example - 2 hours per day, every Monday at 1 p.m.);
  - Dynamic; and
  - Continuous streaming of audio, video, or high speed data.

  A conditional access mechanism ensures that a receiving unit may only access data of which the Network Operations Center (NOC) has individually authorized it to receive. The NOC architecture has been made scaleable and broadcast capacity is allocated based on the broadcast provider’s Committed Information Rate (CIR).

— *Turbo INTERNET:* Turbo INTERNET access allows terminals to be connected to the INTERNET via DirecPC (for packets from the INTERNET) and dial-up model (for packages into the INTERNET). The NOC is connected to an INTERNET Access Provider (IAP) by terrestrial line. The NOC is also connected to the PSTN by a terminal server. Currently, the DirecPC users must either dial into the NOC or into an existing IAP. In the future, mobile users may be able to access the NOC by other means.

As with any telecommunications system, timing is a critical base technology and protocols are enabling/limiting factors. Electronic data can take as long as half a second to travel up and down to Earth from geostationary satellites, which are positioned 25,700 miles away from the planet. Although a delay of that magnitude causes only a slight echo when placing a telephone call, it can wreak havoc when two computers are trying to communicate. The delay causes TCP/IP to believe there is a backup in the network, which in turn disrupts the electronic acknowledgments the receiving computer must relay to the sending computer in order to confirm that messages are being received correctly. Hughes DirecPC works around this limitation by permitting the user to send requests for data directly to the INTERNET by modem. The requested information from the INTERNET flows to back to the Hughes NOC. At the NOC, the data is spooled and the IPA is spoofed. (This provides a larger, more effective TCP window size.) The NOC transmits the data via the Direct Broadcast Satellite (DBS) to the DirecPC VSAT user's computer.

In the near future, DirecPC service will widen its offer to include service to what is known as the Enterprise. DirecPC will then also be installed in servers as well as in standalone PCs. A server based platform extends DirecPC service across the LAN and evolves its current capability of automatically transferring files to the server as they arrive on a separate platform than that of the destination server.

DirecPC's (Hughes') satellite, the Galaxy IV, is a member of the dual-payload, three-axis, body-stabilized HS601 family of spacecraft. It is located at 99 West longitude and provides a variety of satellite services, over 24 channels, to users in the continental U.S., Alaska, Hawaii, and Puerto Rico. Hughes has announced future plans to combine DirecPC and DirecTV systems into one consumer product using one dish. The DirecPC dish will be able to receive the DirecPC signal from Galaxy IV and also from a neighboring DBS satellite broadcasting the DirecTV signal.

Currently, package costs range from $15.95/month plus $.60 per Mb to about $170-200 per month unlimited 24-hour access. A DirecPC access kit costs approximately $899.00 for basic access service only, and $1349.00 for basic access service and the license to receive broadcast services.

Table 4-8, below, shows the components and cost of a typical DirecPC installation. Actual cost may vary depending on the service provider selected.

Table 4-8: DirecPC Facts/Costs

System Requirements	DirecPC Access Kit	Installation	Turbo INTERNET Service
PC w/Pentium Processor	21" Elliptical Dish	Do it yourself = $0	One-time Activation Fee = $49.95
Windows '95	100' of coaxial cable	Ground Mount = $99	Monthly Access Fee = $9.95/mo.
16 Mb of RAM	16-Bit ISA Card	Roof/Wall Mount = $149	Night Surfer Plan = $39.95/mo.
20 Mb free hard disk space	Turbo INTERNET Software	Custom Install = $89/hr.	Day Surfer Plan = $129.95/mo.
Modem (9600 baud or better)	DirecPC Installation		Bulk Plan = 24.95/mo.
A clear line of sight South	DirecPC Users Manuals		Basic Plan = $.60/Mb

(POC: http://www.direcpc.com)

- **Direct Broadcast Satellite:** In the early 1980s, the Federal Communications Commission (FCC) approved the use of commercial broadcast satellites to deliver television broadcasting directly to home receivers, thus bypassing standard commercial television stations and cable operators. The FCC calls this new class of television service "Direct Broadcast Satellite" (DBS). In April 1993, the Navy requested a proposal to demonstrate the feasibility of the new DBS capabilities to support Naval operations and to solve some of the Navy's communications problems. The project was known as "Radiant Storm" and the tests concluded that:

- High data rates can be easily achieved using DBS;
- High power satellite transponders are necessary for military communications in the future;
- High power transponders make VSATs and high data rates possible;
- Encryption works with commercial DBS technology; and
- Very low error rate channels are possible.

A shipboard demonstration of DBS was done in November 1994. This effort was a demonstration of the television capability and did not transfer military data. Ship personnel reported that DBS exhibits outstanding signal quality and interference free operation. The potential exists for near perfection when and if antenna stabilization improvements are made.

Within the military, there is considerable interest in DBS technology. At this time, a military Global Broadcast System (GBS) system is in development, and it should be operational within the next two years. This new GBS will complement, if not replace, the use of Fleet Broadcast for the Navy. The Coast Guard could benefit from the planned GBS, because some, if not most, of the data to be provided by GBS is also required by the Coast Guard. Additionally, the terminal equipment required to receive the GBS is both small in size, including a very small diameter antenna (less than 1 meter) and inexpensive in cost. The data of interest will consist of:

- Warnings;
- Common tactical picture;
- Weather maps and forecasts;
- Theater chart updates;
- Intelligence updates;
- Message traffic; and
- News broadcasts.

Full operational capability is expected by the first quarter of 1999. Until the Full Operational capability is achieved, a Phase I GBS system has been implemented with the one year lease of a high data rate Ku-band transponder on the communications satellite Telstar 402. There is a GBS Phase I user hardware suite that includes a 1 meter dish, a commercial receiver, a rate buffer module that provides the data interface to a user's computer equipment, and a KG-194 cryptographic unit. The cost for this hardware suite is roughly $40,000.

The Navy accomplished a technology demonstration showing high rate data communications (T1) to littoral platforms. In the demonstration, a T1 data rate was achieved to a buoy using a commercial (Seatel) VSAT modified for transmission as well as reception using off-the-shelf commercial components. One of the most interesting aspects of this demonstration was the integration of current cellular CDMA technology. This should allow better use of the available bandwidth from a commercial satellite video channel, potentially up to 30 T1s per channel. This technology should have potential for Coast Guard applications. (C4I Technology Assessment Pg. 95-96)

4.3.2.5 Military Satellite Communications (MILSATCOM)

The mission of MILSATCOM is to provide a survivable, command and control communications system to meet the projected minimum essential wartime operational requirements associated with military communications. In September 1978, the Navy announced a contract award to Hughes Communication Services, Inc., to provide worldwide communications satellite service to DoD. The first satellite was successfully launched in August 1984. Currently, the Navy UHF Fleet Satellite Communications (FLTSATCOM) system consists of a combination of leased and Navy owned satellites that provide world-wide communications connectivity with naval ships and airborne platforms. The FLTSATCOM system comprises space, earth, and control segments. Space and earth segments consist of satellites, earth terminals, subscribers, and subsystems.

As stated in Chapter 2, Coast Guard assets have access to certain MILSATCOM systems based on unique operational requirements and interoperability needs with the Navy. Larger cutters (378 WHECs and 270 WMECs) and some smaller cutters (210 WMECs) are equipped with FLTSATCOM capabilities. FLTSATCOM subsystems most commonly used by Coast Guard units are OTCIXS, CUDIXS/NAVMACS, and FLTBROADCAST (see Chapter 2 for additional information on these systems).

The MILSATCOM system is divided into three general types of communication systems, depending on the frequency range in which the transceiver subsystem operates. These systems are:

- **Ultra High Frequency (UHF):** The UHF satellite system provides communications between suitably equipped mobile units and shore facilities. These links supply worldwide coverage between the latitudes of 70 degrees North and 70 degrees South. The FLTSATCOM system is also deteriorating and is being incrementally replaced by the UHF follow-on (UFO) satellite system. At this time, there are five UFO satellites in orbit and four additional satellites scheduled to be launched. The Coast Guard uses Demand Assigned Multiple Access (DAMA) UHF satellite equipment suites on several classes of ships now. These classes are: 378' WHECs, 270' WMECs, most 210' WMECs, and WAGBs. In addition, the 210' WMECs, currently equipped with non-DAMA SATCOM, are scheduled to receive DAMA SATCOM capabilities during FYs 97-98.

- **Super High Frequency (SHF):** The SHF spectrum is a highly desirable SATCOM medium because it possesses characteristics absent in lower frequency bands, such as wide operating bandwidth, narrow uplink beamwidth, anti-jam, and relatively high data rates. The actual ship-to-shore SHF satellite links are provided by the Defense Satellite Communication System (DSCS). The DSCS is an integral part of the Defense Communications System (DCS), designed to provide vital worldwide communications service to the U.S. and NATO/Allied Forces via satellite.

- **Extremely High Frequency (EHF):** The EHF system provides essential tactical and strategic communications services. It incorporates multiple design features that provide low probability of intercept, anti-jam, survivable, and enduring military communications capabilities. It is designed to meet the minimum essential command, control, and communications requirements of the National Command Authority and strategic and tactical military forces. MILSTAR (Military Strategic, Tactical and Relay) is the name given to the program that developed the use of the EHF frequency band for military SATCOM. Under the MILSTAR program, both space and ground segments of the system were developed. Currently, the term MILSTAR and EHF are used interchangeably when referring to the military EHF communications system. The shipboard terminal also uses one or two antennas. Because of the relatively large physical size of a MILSTAR terminal, its use would not be practical on all but the largest of the Coast Guard ships. An even more important reason that MILSTAR use is not likely for the Coast Guard is the same as the reason that restricts Coast Guard use of UHF and SHF, namely low requirements priority.

Other MILSATCOM systems/technologies include:

- **Military Global Broadcast System (GBS):** This system, currently under development, will use the DSCS to provide GBS to the military using government owned space assets and currently used terminal hardware. The plan is to demonstrate the utility of such a system by moving some of the current UHF and SHF traffic onto the X-band GBS broadcast. The X-band system would provide a limited data rate Navy Broadcast capability. It would also require modfied SHF terminal hardware. The intent is to modify flights of the UFO program to include the high power wideband transponder for the GBS application. The first of these is scheduled to fly late 1997 or 1998. (See VSAT (DirecPC) for more details.) The operational concept is to have some bandwidth set aside for general broadcast (producer-push) similar to Tactical Related Applications Broadcast and Fleet Broadcast (the first two world-wide broadcast systems) and some for query services (user-pull) response. The actual data format is being defined as the frequency of the broadcast with the SHF (X-band) favored over the Ka-band (20 gHz). During recent joint Navy/Marine Corp. tests, data was transmitted over the commercial DBS satellite at a 23 Mbps data rate. Several types of data, mostly tactical intelligence, were successfully transmitted.

- **UHF Demand Assign Multi-Access (DAMA):** This subsystem provides users with increased communications capacity and reliability over dedicated access on the FLTSATCOM satellites. The additional capacity is provided by the time division multiplexing feature of DAMA. DAMA is capable of multiplexing secure voice, record message, and data systems on a single 25kHz satellite channel. DAMA increased the capability of military communications links by time sharing each channel among multiple users. Icebreakers, High Endurance and 270ft Medium Endurance cutters have DAMA, while 210s and the Transportable Communications Centrals (TCCs) are being upgraded to DAMA.

- **Mini-DAMA:** Mini-DAMA is the solution to the UHF DAMA SATCOM requirements of small vessels and C3/surveillance aircraft performing naval or joint operations. Based predominantly on contractor-off-the-shelf (COTS) technology, Mini-DAMA achieves high reliability in a low-cost terminal for DAMA operations. It provides the following features:

  — Interoperability with existing Navy communications systems;

  — Time Division Multiple Access (TDMA)/DAMA for shared use of 5 and 25kHz channels on existing and planned satellite transponders;

  — Eight, full-duplex baseband I/O ports per communications set;

  — Embedded OTCIXS;

  — Simple, menu-driven, flexible operator interface;

  — Over-the-air and field modifiable software;

  — Embedded orderwire encryption; and

  — Multiple embedded COMSEC (ANDVT, KG-84, and KY-57/58) capabilities.

  (Ref: http://www.disa.atd.net/dama)

- **High Speed Fleet Broadcast:** The Navy is currently replacing its out-dated, slow speed (75 baud), multi-channel (16 channels HF/16 channels satellite) fleet broadcast, implemented in 1968, with a new High Speed Fleet Broadcast (HSFB). The HSFB will be capable of speeds of up to 19.2kbps. However, as currently planned, General Service (GENSER) and Sensitive Compartmented Information (SCI) message traffic will run at 2.4kbps, with a total throughput of 9.6kbps. The new HSFB will use a Mil-188-110 modem for HF and a CODEC modem for satellite communications. The HSFB is scheduled for installation on 28 Coast Guard cutters in the 1998-99 timeframe. (POC: LCDR Rohrbach, 703-695-7599)

- **Commercial Satellite Communications Initiative (CSCI)**: Commercial satellite use in the military is growing rapidly. DOD will have an extensive replacement program for satellite communications. Some of that program will be DOD-specfic for security reasons, but it is expected to rely heavily on commercial providers. DISA currently leases commercial transponders through its CSCI contract held by COMSAT (RSI). One visible project is the support of current U. S. Operations in Bosnia. Challenge Athena is another application underway.

(Ref: http://www.fcw.com)

- **Challenge Athena**: Challenge Athena is a commercial satellite (SATCOM) implementation to provide for high bandwidth (T-1 duplex) on carriers and other capital ships in support of intelligence gathering, medical, meteorology and morale and welfare services. This proof of concept prototype has successfully transmitted four radiological images from an aircraft carrier to a shoreside location via SATCOM. The project uses satellites owned by the International Telecommunications Consortium. Challenge Athena's success has encouraged the Navy to consider significant investment in high-data-rate communications to its ships via satellite. (Ref: http://www.matmo.org/pages/projects/navyproj.html)

4.3.3 Cellular Communications

Coast Guard units are demanding more sophisticated services to meet their mobile communications needs. Cellular telephone service can help meet customer needs through a choice of applications and advanced services that were previously available only to wireline subscribers.

4.3.3.1 Circuit-Switched Cellular Networks

The concept of a cellular radio network was first invented by Bell Laboratories back in 1947. It would be over 35 years later before technology caught up with the cellular concept and allowed the first analog networks and terminals to be manufactured.

Fundamentally, a cellular network comprises a series of low power base station sites, each providing a relatively small area of coverage which combines to form contiguous coverage throughout a given area. By employing these low power sites, it becomes possible to re-use frequencies on a more regular basis which provides greater overall capacity to the network.

The coverage provided by each base station corresponds to the number of users that are likely to exist between that area, which is called a cell. Hence, more densely populated areas demand smaller cells and the intelligent aspect of the network provides the ability to allow conversations to continue without interruption as subscribers move between these cells. The process whereby a conversation is passed from one cell to another is known as “hand-off.”

There are over 23 million cellular subscribers around the world and about half of these exist in the U.S. The use of mobile phones is expected to double in the world’s population of cellular subscribers before the end of 1997.

Communicating across circuit-switched cellular networks involves the use of a cellular phone for voice communications or attaching a wireless computer modem to a cellular phone for data communications. Connection via an air-link through a nearby cell, then through the regional switch and ultimately through the telephone network to another computer is continuous until the link terminates when one participant hangs up.

The existing analog cellular network has a huge installed infrastructure providing “seamless” coverage, but only moderate speed (slower than spread-spectrum technology or Cellular Digital Packet Data (CDPD)) and high cost (more expensive, for example, than spread-spectrum or satellite transmission). Transmission of data is billed by the minute rather than by the character or bits-per-second, in some cases yielding up to ten times the price of other wireless services to transmit identical quantities of data. The service offers access to the information services, like INTERNET, America Online, and CompuServe.

For an added cost, you can obtain improved signal-transmission reliability with error correcting protocols which will automatically adjust transmission speed and protect the data from interference.

The following cellular technologies, which are either currently under development or available on the market today, may now, or in the future, meet certain Coast Guard voice, data, and video requirements. (Technologies not currently available in the U.S. should be monitored for future availability.) These technologies may be discussed in greater detail in Chapter 5.

- **Universal Mobile Telecommunication System (UMTS):** The Universal Mobile Telecommunications System (UMTS) is a new technology, third generation portable communication system, currently being developed in Europe. Some requirements for UMTS are:

    - To support existing portable services and fixed telecommunications services up to 2 Mbps;
    - To support unique portable services, such as navigation, vehicle location, and road traffic information services;
    - To allow the UMTS terminal to be used anywhere, in the home, office, and public environment, both in rural areas and city centers; and to offer a range of transportable terminals from a low cost pocket telephone (to be used by almost anyone, anywhere) to sophisticated terminals to provide advanced

video and data services. (C4I Communications Technology Assessment Pg. 43)

- **<u>Global System for Mobile Communications (GSM)</u>**: The Global System for Mobile Communications (GSM) is a new technology, digital cellular communications system which has rapidly gained acceptance and market share worldwide, although it was initially developed in a European context. In addition to digital transmission, GSM incorporates many advanced services and features, including ISDN compatibility and worldwide roaming in other GSM networks. The advanced services and architecture of GSM have made it a model for future third-generation cellular systems, such as UMTS.

  The system meets the following criteria:

  - Good subjective speech quality;
  - Low terminal and service cost;
  - Support for international roaming;
  - Ability to support handheld terminals;
  - Support for a range of new services and facilities;
  - Spectral efficiency; and
  - ISDN compatibility.

  Commercial service was started in mid-1991, and by 1993 there were 36 GSM networks in 22 countries, with 25 additional countries having already selected or considering GSM. Although standardized in Europe, GSM is not only a European standard. GSM networks are operational or planned in almost 60 countries in Europe, the Middle East, the Far East, Africa, South America, and Australia. In the beginning of 1994, there were 1.3 million subscribers worldwide. By the beginning of 1995, there were over 5 million subscribers. (C4I Communications Technology Assessment Pg. 44)

  Primary advantages of GSM:

  - Increased radio spectrum efficiency to provide even greater network capacity (supports a high amount of subscribers);
  - Provides highly sophisticated subscriber authentication;
  - Prevents the eavesdropping of conversations by employing sophisticated voice encryption techniques which are totally secure;
  - Provides better voice clarity and consistency, emanating interference due to digital transmission (turns speech into binary numbers);

- Simplifies the transmission of data which allows the connection of laptop and palmtop computers to GSM cellular phones;
- A single standard allowing International Roaming between the world's GSM networks; and
- One phone - one number.

GSM networks operate in the frequency range 890-915/935-960 MHz by means of 140 duplex radio channels, each of which is 200 kHz in bandwidth. The frequency split between these two bands is 45 MHz which is also the bandwidth between the transmit and receive frequency of the GSM terminal.

A technique known as Time Division Multiple Access (TDMA) is used to split this 200 kHz radio channel into 8 time slots, each of which constitutes a separate voice channel. Unlike normal analogue signals, the transmission of a voice channel is not continuous. By employing 8 time slots, each channel transmits the digitized speech in a series of short bursts, each of which adds up to a total of one eighth of a second. Hence a GSM terminal is only ever transmitting for one eighth of the time.

The advantage of TDMA with its system of time slots is that you can re-use frequencies within a closer proximity as there is less probability of interference. This provides greater efficiency which, in turn, allows the accommodation of more users.

4.3.3.2 Cellular Digital Packet Data (CDPD)

CDPD, offered by several providers, including Tellabs Wireless Systems, uses the already well-established cellular phone network for wireless data transmission. This means that CDPD works on top of, or along side the cellular telephone system. CDPD uses the same radio spectrum as the cellular telephone system and can use the same radio engineering designs as the cellular telephone system.

The benefits of this approach to developing a wireless data network is twofold. First, it allows the device manufacturers to develop equipment based on proven radio technologies. Second, it allows the service providers to re-use much of their existing infrastructure. This is not to say that CDPD is all old technologies. In fact, CDPD is a digital system. It encodes all data into digital transmission bursts and transfers these bursts over the air efficiently. Part of this efficiency comes from using a forward error correction scheme in all data transmissions. By using forward error correction methods, there is a reduction in the need to repeat lightly corrupted data bursts. Retransmissions are only necessary when the data block is damaged beyond repair.

Another efficiency improvement comes from the recognition that CDPD is a data network. Data communications are typically bursty in nature. CDPD makes use of this characteristic by packetizing the data transmissions and allowing multiple devices to share the same radio channel. Orderly sharing of the channel is managed by the Medium Access Control scheme.

Coverage is currently minimal, but eventually should be identical to the existing cellular network. This may be years away. There is much debate among analysts as to when it will be fully operational. Service providers are in the early process of building the regional infrastructures and at the same time, are beginning to interconnect the separate regions into national network. The actual scale of CDPD adoption will be very dependent on the total cost of end user solutions which in turn will be dependent on the price charged by the service providers, and the extent to which the need for custom software can be minimized via the use of packaged software.

The speed users of CDPD can expect is a 1-5 second response time and raw data rate of 10.2kbps, and a sustained user throughput on the order of 9.6kbps. Security for CDPD is reasonable, since eavesdropping on the network is difficult.

The cost of CDPD is cheaper than switched cellular for the short messages typical of e-mail (less than 2-5 kb). Users are billed according to the amount of data transferred rather than by connection time or distance. Cost will probably be $.05 per kb, with 100 kb file costing close to $20 to transfer and a short e-mail around $.20.

Since the newer digital CDMA system can deliver data at 56kbps as opposed to CDPD’s 19.2kbps, CDMA is seen by many in the industry as the logical successor, especially since security services in the CDPD protocol can reduce effective throughput to approximately 11-12kbps and since the CDMA frequency hopping protocol offers inherent security.

(Ref: http://www.raleigh.ibm.com.cel.celmel.html)

4.3.3.3 TDMA/CDMA/Steinbrecher Microcells:

The current Advanced Mobile Phone System (AMPS) cellular system is now yielding to the alternative TDMA and CDMA digital technologies. TDMA and CDMA are candidate technologies for the emerging Personal Communications Services (PCS) initiative. CDMA inherently offers greater room for improvement than TDMA does. While TDMA attempts to narrowly slice frequency bands, CDMA allows multiple frequencies to be used simultaneously. CDMA is inherently difficult to intercept since its 30 kHz cellular channel, is spread across a comparatively huge 12.5 MHz swath of the cellular spectrum. Many users share the same spectrum space at one time, since each phone is programmed with a specific pseudo-noise code, which is used to stretch a low-powered signal over a wide frequency band. The base station uses the same code in inverted form to “de-spread” and reconstitute the original signal. All other codes remain spread out, indistinguishable from background noise.

Both TDMA and CDMA technologies are equally applicable to the new PCS microcells, as well as to other types of wireless networks, but CDMA was the first to meet the tenfold call-carrying capacity increase that the industry originally called for. It can, in fact, provide up to a twenty-fold increase by assigning each call a unique code using up to 1/1000th of the required power compared to TDMA-based systems.

TDMA multiplexes up to three conversations over a 30 kHz transmission channel. It was seen as a quick start technology because it already had an established GSM market-base in Europe. As a result, TDMA was selected in 1989 as a digital cellular standard. Unfortunately, TDMA's three-fold increase in capacity has provided far less than the required ten-fold increase, and efforts are underway to increase its capacity.

CDMA technology, on the other hand, replaces frequency shuffling with digital intelligence. Supplanting the multiple radios of TDMA, where each connection exists on a fixed frequency, with digital-signal-processing that can find a particular message across a wide spectrum captured by one broadband radio. CDMA, in concert with the new Steinbrecher microcell appear to offer the potential to be technology leaders for the wireless industry. Rather than tuning into one fixed frequency, as current cellular radios do, Steinbrecher's microcells can use a high-dynamic-range digital radio to down-convert and digitize the entire cellular band. TDMA, CDMA, near or far, analog cellular, video, voice or data, in any combination, it makes no difference to the Steinbrecher system. Steinbrecher microcells convert them into a digital bit stream. Digital signal processors then sort out the TDMA and CDMA signals from the analog signals and reduce each to digital voice.

To the extent the Steinbrecher system prevails, it would end the need for hybrid phones and make possible a phased shift to personal communications network or a variety of other digital services. Steinbrecher radios could also facilitate the acceptance of CDMA. For CDMA, the microcell provides a new, far cheaper radio front end that is open to the diverse codes and fast-moving technologies of personal communications networks.

For the current cellular architecture, however, Steinbrecher microcells offers only creative destruction, doing for large base stations what the integrated circuit did for racks of vacuum tubes in old telephone switches.

The deployment of Steinbrecher microcells can significantly impact Coast Guard use of cellular service. The evolution of the cellular infrastructure from cells that require "high power" (600mw) link signal to the 6mw link microcell structure could impact the Coast Guard by reducing the effectiveness of cellular service in littoral areas where no microcells are available beyond coastal outlines.

The evolution to microcell technology may require the Coast Guard to deploy microcells aboard vessels, since the inter-cell links are not subject to the same low-power broadcast constraints as the hand-held phone to cell link. Also, the entire scope of this problem changes with the deployment of LEOS assets where potential to access space-based cells using a 0.7w signal from a hand-held cell phone will truly offer global connectivity. (C4I Technology Assessment, Pg. 39-40)

Several companies are currently deploying commercial CDMA service in the U.S. These include:

- <u>AirTouch</u> which introduced Powerband digital cellular service in Los Angeles. Powerband is the first large-scale commercial service offering in the U.S. based on

CDMA technology. Initial Powerband service in Los Angeles employs network infrastructure from Motorola and handsets from OKI and Qualcom Personal Electronics. The Powerband network will be comprised of more than 200 cell sites when the system is completed. Powerband has an average of nine times the call capacity of current analog systems.

- Bell Atlantic launched its commercial CDMA digital service in Trenton, New Jersey and Bucks County, Pennsylvania. Bell Atlantic NYNEX Mobile (BANM) reports a high level of customer satisfaction with the service. Currently, customers are paying $40 a month for unlimited calling in the 17 cell site area. Customers are particularly pleased with the superior voice quality. BANM's network provides eight to nine times the call capacity of existing analog networks. Furthermore, the system stability has exceeded expectations, with availability in excess of 99.8 percent. To take full advantage of CDMA's unique network characteristics, BANM employs a one-to-one analog to digital overlay in its cell sites. BANM engineers find that a one-to-one overlay allows for consistently better voice quality and considerably lower incidence of dropped calls.

- 360° Communications Company began offering CDMA service to its Las Vegas cellular customers. CDMA technology will enable 360° Communications to increase its network capacity to meet expected customer growth in Las Vegas, an area of extremely high cellular phone usage. The CDMA network has at least six times the call handling capacity of analog technology. Motorola provided the infrastructure and switching equipment for 360° Communications' entire network in Las Vegas. Qualcomm Personal Electronics furnished the dual-mode CDMA digital handsets for the service.

- GTE announced that it is conducting customer trials of CDMA technology in its Austin, Texas wireless market. The trials are intended to educate customers about CDMA technology and evaluate customer acceptance of voice quality and features, such as Caller ID and numeric paging. The customer acceptance testing follows operational reliability testing by GTE in the Austin market. Later this year, GTE will introduce a CDMA-based system in its San Jose, California market. Deployment in other major markets will commence in the near future.

4.3.3.4 Microcells

In cellular networks, any given area is segmented into cells with each having its own base station. The network design determines how many cells there are and how large an area they cover. Macrocells may have a range of 3 KM and a power of 6 Watts. Microcells are advertised with a range of .3 KM and a power of .6 Watt. The smallest of the cells are the picocells at a range of .06 KM and a power of .03 Watt. Other things being equal, smaller cell areas allow for higher traffic capacity. With smaller cell areas, the cost could rise since more base stations would have to be constructed and operated.

Current systems use macrocells, but future designs will use micro- and picocells. These microcell wireless access systems use fundamentally similar radio technology as compared to their bigger brothers the macrocells only with the reduced cell size (3 KM radius vs .3 KM radius). In the mobile environment the implication is that microcells have no inherent unit cost advantages over macrocells. Network operators should take care in making the switch from macro to micro only when capacity constraints require it.

Cell size implications in the maritime environment may mean a reduction in cellular coverage seaward if more systems convert to micro- or picocells. This should especially be true in metropolitan areas, where capacity requirements may force smaller cell sizes sooner. (Ref: http://www.wyoming.com)

4.3.3.5 CONDOR

CONDOR, offered by Qualcom Inc., is a secure, multi-mode hand-held cellular device that is capable of a broadcast mode. This system is designed to be used as a vital, secure communication system in Joint Services and covert activities. CONDOR may be poised to be extremely attractive to Coast Guard planners. A fully functional CONDOR, operating according to current designs, could provide the Coast Guard with an inexpensive automatic GPS locator system for emergency situations. A CONDOR unit can interoperate with:

- STU-III units;
- STU-IV units, also known as STE units;
- Cellular phone and pager service;
- FAX;
- E-mail; and
- Broadcast groups in a land mobile radio-like cellular broadcast arrangement.

In addition, the CONDOR unit offers features for:

- Local address book;
- Calendar;
- World time clock;
- Standard and predictive keyboards calculator;
- Paperless note pad;
- Appointment scheduler;
- Handwriting annotation; and
- Position locator that is accurate up to 100 meters.

These capabilities and features are available in a unit that is 2.5” wide, 1” deep, 8” long, and weighs only 18oz. The CONDOR unit can connect to local cells for local distribution or communicate world-wide via satellite when the Globalstar Low Earth Orbit Satellite (LEO) systems begin to deploy.

The CONDOR unit uses the FORTEZZA+ card to support STU-III interaction and to support secure Advanced Mobile Phone System (AMPS), Wideband Code CDMA, and Land Mobile Radio (LMR)-like communications.

The Federal Bureau of Investigation (FBI) has invested well over $10M in the development of this unit. They plan to make this the backbone of their various field units because of its versatility. It is felt that because of the support of this unit, by the FBI, and the importance of access to information in FBI files and data bases, **CONDOR will be recognized as the standard unit for law enforcement.**

The use of the CONDOR unit in the non-secure mode may be of considerable interest to the Coast Guard, since its use by the Coast Guard will interoperate with cellular phones readily available to the public, and thus reduce or eliminate mandates that the public buy specific safety equipment. The public may voluntarily migrate to cellular phone use out of self interest.

Table 4-9, below, (C4I Communications Technology Assessment pg. 42) shows how the flexibility of CONDOR prepares it to participate in a range of Coast Guard missions.

Table 4-9: CONDOR Mission Area Applicability

Mission Area	Condor Capability
Meet distress coordination, and command and control requirements in coastal areas and navigable waterways where commercial or recreational traffic exists.	The CONDOR system, with the advent of the Globalstar (LEOS) system, will provide world-wide coverage. The CONDOR is designed to automatically select cell or satellit readability.
Disseminate marine safety information.	The paging system or LMR broadcast modes could be use
Respond to crisis operations and provide sufficient voice channel and data communications capacity to support multiple operations.	The CONDOR system, using Spread Spectrum and CDMA make better utilization of the frequencies that have been allotted for the cellular phone system. This therefore provides for more users by a factor of 10.
Aid in searches for vessels that do not report, don't know, o incorrectly report their position, and assist in the prosecutio of hoaxes.	With the insertion of the GPS PCMCIA card in the CONDOR, it is possible to automatically relay location information to a Coast Guard station.
Record and time stamp voice re-transmissions and instantl play back incoming voice transmissions.	The CONDOR could incorporate voice mail with the pager function in the unit requesting that the caller enter their pho number for recall.
Allow communications with federal, state, and local government agencies.	If the cost of the CONDOR is in the price range of less than $200, it will be used by many of the federal, state, and loca government agencies.
Protect the transmission of sensitive information.	The CONDOR system with the FORTEZZA+ card, will allov for encrypted data with protective keys to protect sensitive data.
Collect and disseminate intelligence and environmental monitoring/compliance data to/from mariners.	Using the CONDOR in the LMR mode will allow the Coast Guard to perform this function.

POC: Jim Treadway at Qualcomm Inc. (619) 658-2716)

There are several issues that represent a less desirable side of cellular phone use. Let's first look back to when Dick Tracy talked into his wrist. He had a little radio (and eventually, a tiny television) strapped there. The signal leapt, by the magic of comics, from Tracy's wrist to a satellite perched visibly over the buildings of the city like a Budweiser blimp. He could talk to anyone, from anywhere, because of that satellite. By now we are used to people flipping open cellular phones in restaurants, on ferries, in theaters, etc. But, Dick Tracy would have tossed today's cellular phones into a desk drawer and stuck with his wrist gizmo. Why? Today's cellular phones have ghosts and cross-talk. The spectrum is crowded. Other people can overhear—the underworld can certainly afford scanners. Sometimes when one "cell" hands you off to another, you get dropped like a trapeze artist with a timing problem. A cellular phone can't always call everywhere. A cellular phone can't easily leave town, and if you do, you pay extra to "roam."

4.3.4 Joint Maritime Communications Strategy (JMCOMS)

JMCOMS represents a revolution in Naval communications. It allows for a broad evaluation of the products and services needed to satisfy a multitude of evolving mission requirements. This approach leverages the latest advances in communications technology, commercial or military, and maximizes the utilization of communications assets and scarce bandwidth. JMCOMS is both a technical and program strategy that implements the communications portion of the Navy's Copernicus architecture for C4I. It will leverage COTS solutions and field user-pull, flexible, interoperable, multifunctional communications systems.

The JMCOMS Technical Strategy consists of three elements: the Automated Digital Network System (ADNS), the Digital Modular Radio (DMR) System (sometimes referred to as "Slice" Radio), and the Integrated Terminal Program (ITP).

- **Automated Digital Network System (ADNS):** The ADNS, which is the key to JMCOMS, will provide efficient networking and automation capabilities, and will ensure world-wide communications connectivity via radio frequency (RF) communications assets included in DMR and ITP. ADNS will leverage industry accepted standards for communications routing, switching, and management, and will employ COTS/GOTS hardware and software to provide timely, efficient, and seamless data delivery to and from all data users. ADNS networking capabilities will allow for the sharing of scarce communications bandwidth and will reduce reliance on "stovepipe" communications systems and dedicated bandwidth allocations. ADNS will effectively "pool" communications resources and remedy the problems caused by overloading or underutilization of communications circuits. Overall, ADNS maximizes information transfer efficiency and provides seamless afloat/ashore voice, video, and data networks for world-wide, interoperable communications.

- **Digital Modular Radio (DMR) System:** DMR will satisfy tactical communications requirements in the High Frequency (HF), Very High Frequency (VHF), and Ultra High Frequency (UHF) ranges. DMR will reduce the cost of acquiring and upgrading communications systems and will increase tactical flexibility. The DMR System will migrate from stand-alone, "stovepipe" terminal systems to a modular radio comprised of flexible, software configurable hardware modules. DMR will permit the on-scene-commander to reconfigure radio assets in accordance with changing mission needs. DMR will be compatible with ADNS for network control and monitoring capabilities. In addition, the DMR System will field integrated, multiband antennas that will reduce topside space and weight, and will lessen ship radar cross section. In short, DMR will provide affordable, flexible, interoperable, demand adaptive communications.

- **Integrated Terminal Program (ITP):** ITP will provide flexible and responsive subsystems and terminal equipment that will enable protected narrowband and wideband communications connectivity. ITP will satisfy communications requirements in the SHF, EHF, and commercial SATCOM frequency bands. This program will field a collection of military and commercial products that will evolve to further the JMCOMS objectives of providing increased communications connectivity and Joint interoperability. ITP will leverage commercial terminal systems and services, such as C- and Ku-band SATCOM, Direct Broadcast Satellite Service

(DBSS), INMARSAT, and GBS to support high data rate requirements for voice, data, imagery, and video (i.e., intelligence, weather, live video, news). ITP will place emphasis on COTS/GOTS components and will pursue "plug and play" modular terminal configurations. ITP capabilities, integrated with ADNS and DMR, will provide adaptable, Joint interoperable, protected, and high capacity communications at less cost.

(POC: http://www.spawar.navy.mil/pmw176)

4.3.5 Traditional Wireless Communications

With the advent of DoD Fleet Satellite Communications (FLTSATCOM), coupled with rapidly changing and improving satellite technology, SATCOM has become the primary carrier of global military communications. The existing HF network has assumed a secondary, albeit important, backup role in DoD. This is generally the case for larger Coast Guard cutters as well (i.e., 378s and 270s). However, the Coast Guard still relies heavily on HF as the primary means of passing record message traffic on smaller cutters (i.e., 210s and below).

It is now considered normal procedure for larger cutters (378 WHECs and 270 WMECs) to copy the Navy FLTSATCOM broadcast, while underway, and to also send their message traffic via Navy satellite circuits. Even the smaller 210 WMECs have satellite communications capabilities for copying the recently established Coast Guard Fleet Satellite Broadcast (LMCG). However, since the LMCG is a one-way, shore-to-ship broadcast system, the ship's outgoing message traffic is still sent via HF on-call radioteletype (RATT) circuits to a Coast Guard Communication Station (COMMSTA).

Smaller cutters (i.e., 110 WPBs) are not equipped to send or receive record message traffic via satellite. Therefore, their primary means of sending and receiving messages is the Coast Guard developed High Frequency Data Link (HFDL), a secure (KG-84), polled, packet-switched, wide-area data network that operates over HF radio..

The C4I Communications Technology document, developed by the C4I and Sensors Project Staff, indicates that several of the Coast Guard's primary mission areas have strong HF communications requirements. These mission areas include:

- Contingency Preparedness/Defense Operations (CP/DO;
- Enforcement of Laws and Treaties (ELT);
- Ice Operations and Marine Science Activities (IO/MSA;

- Search and Rescue (SAR); and
- Waterways Management and Aids to Navigation (WWM/ATON).

The primary HF communications requirements include the need for:

- Medium to high data rate Serial Tone Modems (STMs);
- Message processing systems interoperable with the Navy HF message delivery systems;
- Fast tuning, rapid frequency shift radios with ALE controllers;
- Secure voice and message communications;
- DSC installation;
- Improved equipment reliability and maintainability;
- Common crypto and crypto keylists; and
- Real-time data link for command and control of own units in local and multi-national operations.

The problem is that the most of these mission areas is now suffering from the lack of communications interoperability with the Navy. This is primarily due to the Navy's HF improvement process which has inserted new HF technology into the command and control systems, including HF Automatic Link Establishment (ALE), High Speed Fleet Broadcast (HSFB), and advanced HF radio systems with fast tuning capabilities (discussed later in this Section).

In addition, both the Navy and the Coast Guard have documented that certain cutters, particularly the 210' WMECs, do not have the communications capability to operate effectively together. Cutters and aircraft have requirements to communicate with their operational commanders. This requires rapid, secure communications which do not exist at this time.

Several new technologies can and will provide much needed improvements to the current HF system. Some of these new technologies are discussed below, based on information provided by the C4I Technology Assessment document dated 7 August 1996.

- **HF Transmitters:** Over the past several years, HF communications technology has made significant advances, and has again become a viable alternative for long-haul communications. New transmitter technology has replaced the large, slow, manually tuned transmitters of the past. These new transmitters are capable of fast tuning, with memory channels that permit rapid frequency shifts, and support other technologies, such as ALE. New transmitters can be controlled remotely using standard physical interfaces from either PCs or remote control units (i.e., COMMSTA Control System). The Coast Guard is currently replacing many of their old Rockwell HF80 transmitters with new Harris 750A 10kw transmitters, at a cost of approximately $77,000 each.

- **<u>HF Receivers:</u>** New HF receivers are solid state tuners with automatic digital controllers and pre-stored memory channels. These receivers typically have 100 channels of memory with pre-stored frequencies that permit rapid tuning. Tuning to new, non-prestored frequencies can be accomplished in fractions of seconds. Enhancements, such as digital signal processors (DSPs) have been introduced to increase accuracy and speed of received signal processing. The receivers are capable of multiple modes of operations, including the traditional Upper SideBand (USB), Lower SideBand (LSB), and Independent SideBand (ISB), and have built-in preselectors to reject strong signals from generating image signals.

- **<u>HF Transceivers:</u>** Old transceiver technology consisted of a transmitter or exciter and a receiver built into the same chassis with a transmit/receive switch to prevent receiver front-end selectors from being overloaded and destroyed. The transceiver components had the same characteristics as the individual components would have had if broken out into independent transmitters and receivers (i.e., slow, manual tuning, etc.). Old transceivers typically came with manually tuned couplers or remote couplers. New transceiver technology includes:

  - Auto-tuning;
  - Built-in preselectors to counter strong signals producing image frequencies;
  - Rapid tuning;
  - Built-in modems;
  - ALE; and
  - Memory channels for transmit and receive preset frequency storage.

  All transceivers are smaller than the generation they are replacing, and usually fit into a standard 19 inch rack. Some of the smaller units will fit on table tops, and are suitable for installation on small vessels. Transceivers are designed to operate in half-duplex or simplex modes of operations only, though it is within the means of the technology to build an offset receiver to provide full-duplex operations. Future technologies appear to be headed towards automatic control, greater efficiency and greater reliability.

- **<u>HF Modems:</u>** Older modems were independently setup and patched to supporting equipments, where record message traffic primarily used multi-tone modems. New modems support multiple modes of operations with greater power.

  The Navy has developed a new modem, the HF Data System (HFDS), which will be installed on high and medium endurance cutters, and on icebreakers. The HFDS can transfer data at speeds up to 2400 bps. Testing supports the expectation that 1200 bps could be expected under most circumstances, even with low power shipboard transmitters.

Another new modem technology is the ALE modem/controller. This modem is unique in that it controls multiple tasks associated with establishing connectivity automatically. This is done by sounding to determine the best frequencies available for a given service, performing link quality assessments on frequencies tested for connectivity between two points, and determining what platforms are able to communicate with the challenging or master station.

Future modem technologies appear to be headed for ALE networking vice point-to-point protocols, better automatic repeat request capabilities, and some exploration of spread spectrum waveforms.

ALE appears to work well in DoD, in a task group-type environment. However, was tested in the Coast Guard, a few years ago, and did not prove acceptable for Coast Guard multi-mission operations, especially where units may be required to communicate with the maritime public and other government, private, and public agencies.

- **HF Couplers:** The old couplers were slow, manually tuned multi-couplers, with some remote control capability. Some had motorized tuning capabilities, but none were digitally controlled and few had an automatic tuning capability to support transceivers. Older transmitter couplers are tuned by transmitting a signal through the coupler to the antenna and manually tuning until a peak or null indication is read on a dial, or by pushing a button until the coupler matches up impedance.

  New coupler systems are rapid tuning, digitally controlled couplers associated primarily with whip antenna systems. Some new technology couplers, that are adaptive and selective for both narrowband whips and broadband fan antennas, are emerging. These future couplers, which are still proprietary, seem to be evenly divided into two areas: multi-couplers for broadband antennas and narrowband couplers for whips and active antennas.

- **HF Antennas:** Little change has occurred in HF antenna technology in recent years. Some types of antennas have been removed from ships, and others, such as the loop antenna, have fallen from favor as transmitting elements. This was primarily due to their lack of omni-directional coverage, a requirement now considered important to mobile unit applications. The mainstays of antenna technology remains the narrowband whip and wire antennas, along with the broadband fan.

  Two new antenna technologies are just emerging and have not yet been tested. They include a whip antenna that has been optimized for use of higher frequencies for surfacewave paths, and a new broadband fan that is expected to have a more uniform impedance across the full HF operating spectrum.

- **HF Broadband Technology:** Broadband HF is a relatively new technology being introduced into major Navy command ships. The first broadband system in the Navy provided multiple HF circuit output to broadband antenna systems, and a broadband receive system to support multiple HF receive requirements. A limited number of narrowband components are included in the broadband system to handle Link-11. A newer broadband system has been designed by Harris based on the company's broadband system installed in Canadian frigates. The new system is more flexible than the old system, and comes in several configurations to match the platform's circuit requirements. Existing broadband systems are being backfitted with ALE capability. Future broadband technology appears to be looking at a means of reducing costs of current technology, and ways of integrating this technology into force operations, rather than developing a new broadband architecture.

- **HF Narrowband Technology:** Transmitter and receiver narrowband architectures are the most commonly used architectures used by the Navy and Coast Guard. These architectures provide advantages for:

  - Flexibility in design and upgrade;
  - Less expensive to procure;
  - Less expensive to install;
  - Only minor changes to the logistic system needed as new components replace older ones; and
  - Supports full-duplex operations.

  However, narrowband transmitter and receiver architecture is more difficult to automate due to the increased numbers of control lines required, and it may require more control software to be written to support different message format requirements. In addition, it does not support ALE from the perspective of requiring different antennas for the transmitter and the receiver, each with its unique radiation pattern, and it requires additional personnel staffing due to the patching requirements.

The Navy has issued a new HF policy designating HF as the media of choice for intra/interforce communications and for communicating with allied and coalition naval forces, as well as to support back-up ship-shore HF communications. One of the highest priorities in the National strategy, is to conduct all military operations as Joint operations, if only the U.S. is involved, or as combined operations, if allied or coalition forces are involved. In all cases, interoperability is the key word (discussed in greater detail in the next Section), and must be considered when selecting future voice, data, and video technologies. (C4I Interoperability Assessment Pg. 166)

Global Maritime Distress and Safety System (GMDSS)

The GMDSS is not a "system" in the conventional, communications sense, but rather an integrated approach for improving maritime safety and communications. This consolidated effort is planned to upgrade and enhance the following types of maritime operations:

- Alerting;
- Locating;
- On-scene SAR Communications;
- Meteorological, navigational, and urgent information;
- VHF-FM Bridge-to-Bridge communications; and
- General Business Communications.

The elements of the GMDSS, when implemented, will result in significant improvements in communications support for the above activities. All of these elements and the implementation requirements are defined by amendments to the 1988 Safety of Life at Sea (SOLAS). These agreements require certain types of communications systems/hardware to be installed on selected classes of vessels. The specific communications required are further defined by the ocean areas in which the vessel is operating. These operating areas are also defined in the agreements that implemented the GMDSS.

Several elements of GMDSS will have an impact on Coast Guard communications. The most significant of these elements are as follows:

- **Digital Selective Calling (DSC):** DSC is an alerting and radio circuit establishment feature that enables automatic initialization of communications between transmitters and receivers. (It is analogous to dialing a telephone number over the commercial telephone system.) Stations are notified of incoming traffic when their communications equipment receives the DSC data stream. DSC is envisioned for installation on Coast Guard Medium Frequency (MF), HF, and VHF (Channel 70) systems ashore and afloat. Prototype HF and VHF DSC systems have been installed at several Coast Guard locations for testing.

- **World-wide Navigational Warning Service (NAVTEX):** NAVTEX is the international standard for data transmission over MF, and has similar features and capabilities to Simplex Teletype Over Radio (SITOR), described below. Broadcasts, of urgent navigational, weather, and other warning information, are transmitted by Coast Guard COMMSTAs at scheduled times each day, in digital format, on 518kHz. It is essentially automated and runs on a Coast Guard Standard Workstation (CGSW). The Coast Guard currently provides this service to the maritime public and will continue to do so for the foreseeable future.

- **Simplex Teletype Over Radio (SITOR):** SITOR is the international maritime standard for transmission of data via HF radio. As the standard, it is used for the following:

  - All ship-shore, unclassified message traffic;
  - Non-voice distress communications; and

— Communications with the civil maritime community, including NOAA and foreign military vessels.

SITOR capability is already installed at the COMMSTAs and is planned for installation on WLB, WAGB, WHEC, and WMEC cutters.

- **INMARSAT:** Satellite communications capability is also required for commercial vessels under the GMDSS agreements. The vessel class and its ocean operating area determine which type of INMARSAT capability is required.
- **Impact of GMDSS on the Coast Guard:** International agreements require all SOLAS vessels to be capable of DSC operation on all of their radio communications not later than February 1999. The automatic nature of DSC operations will affect both radio operations procedures and personnel requirements. After February 1999, vessels meeting GMDSS DSC requirements are no longer required to guard Channel 16 VHF-FM. However, recreational boaters, and certain other maritime vessels, are not required under the SOLAS agreement to carry DSC. Therefore, the Coast Guard will still be required to maintain a VHF-FM distress guard on Channel 16 for non-DSC equipped vessels.

  — As elements of the GMDSS are implemented and integrated into the Coast Guard COMMSYS, voice communications over the System Coordination Network (SCN), 2182kHz, and VHF-FM Channel 16 may be phased out or discontinued.

4.3.6 Tactical Defense Message System (DMS)

As implementation of the Defense Message System (DMS) begins in earnest, at many shore commands, a question often asked is “What is the plan for ships?”

The Navy is committed to providing full DMS capability to ships and submarines. In many ways, the shipboard architecture may be similar to a shore command. However, since ships have more constrained and unique operating environments, the proposed implementation strategy and schedule will be different. Plans for tactical DMS have not been finalized.

The Navy plans to field Global Broadcast System (GBS) receive terminals on all classes of ships and submarines down to Coastal Patrol Craft. Within the next several years, however, the Navy will bring greater capability to more ships by fielding such programs as EHF Medium Data Rate terminals, more UHF/VHF radios and GBS terminals. DoD has also started fielding the Automated Digital Networking System (ADNS), which extends the NIPRNET (and its SECRET counterpart, the SIPRNET) to battlegroups and amphibious readiness groups.

It's expected that all surface ships will be able to receive the GBS by the year 2003. The goal is to have broadcast capability incorporated into the DMS components by FY99.

The NAVMACS system provides message processing and distribution aboard surface ships today. NAVMACS sends and receives messages in a variety of formats over different paths, such as Fleet Broadcast, CUDIXS. The NAVMACS systems are in the process of being replaced by NAVMACS II. NAVMACS II provides greater functionality at a cheaper cost using COTS equipment which users can access via existing shipboard LANs.

Since the NAVMACS II configuration of messaging file servers, with users connected to LANs, is very similar to the DMS philosophy, the Navy based its surface ship implementation strategy on evolving NAVMACS II to host DMS components.

For security purposes, each user will have a FORTEZZA card to access the DMS.

The NAVMACS II system, with DMS components, will provide flexibility in sending/receiving messages. As ADNS is fielded, and when bandwidth is available, NAVMACS II will receive messages in DMS format directly over the SIPRNET/NIPRNET backbone. Yet if needed, NAVMACS II will still be able to receive in the old formats (i.e., Fleet Broadcast, CUDIXS, etc.). The MultiFunction Interpreter (MFI), that will be included in NAVMACS II, will convert these old formats to DMS prior to sending them on to the user.

DMS messaging, aboard ship, will depend on a dedicated shore infrastructure. The NCTAMS currently provide the fleet gateways for AUTODIN messaging, and it is envisioned that they will continue in this role for DMS.

Technology for DMS, including bandwidth needed for surface ships, is here today.

To the shore user, the critical date is the closure of AUTODIN by December 1999. Through the use of an MFI, however, ships will be able to continue to receive message traffic in the current formats for as long as necessary. Eventually, ships will be able to send and receive DMS directly, all the time, to other DoD users. (POC: LCDR Bryant (703) 602-8361)

Figure 4-9 shows the proposed architecture for ship-shore DMS.

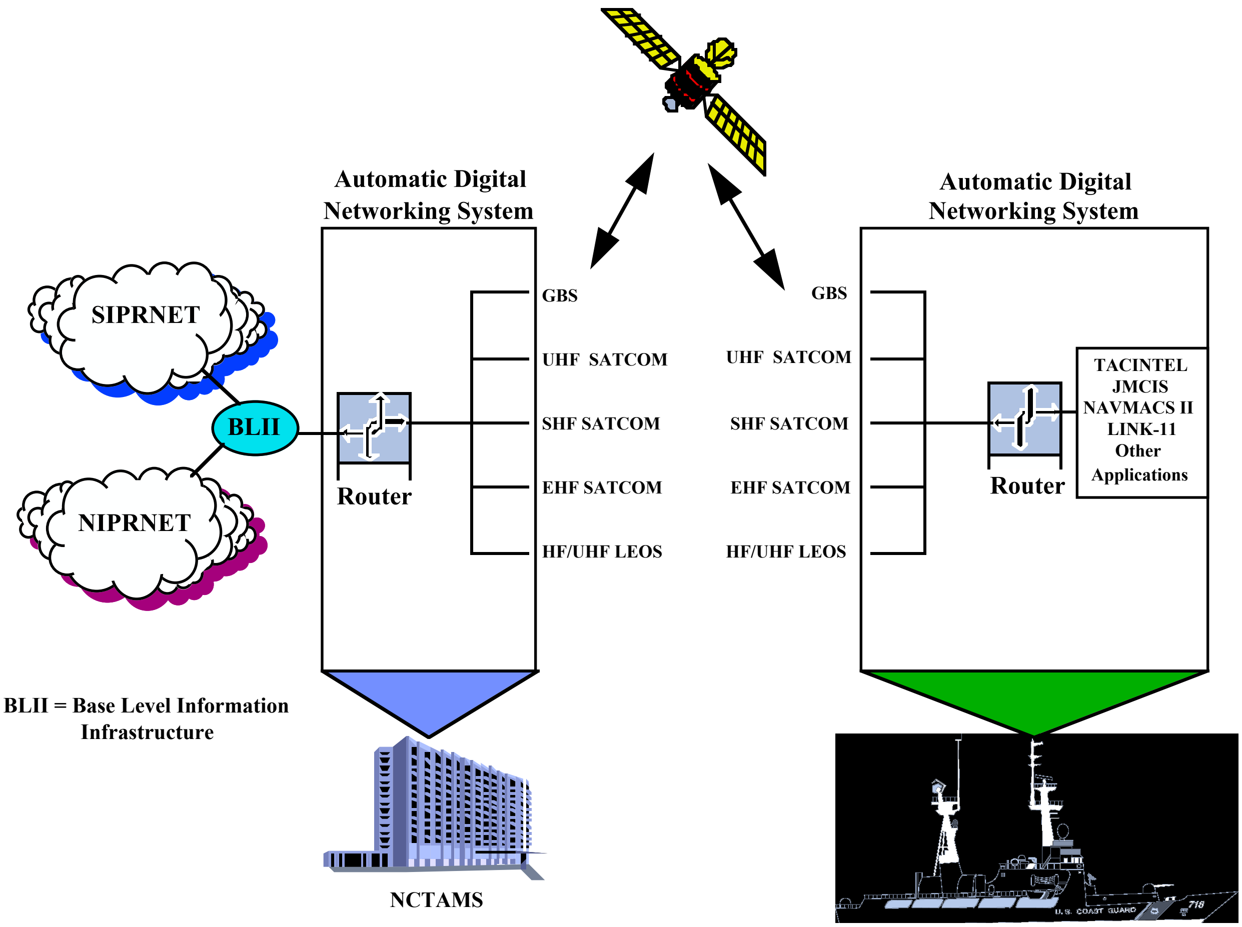


Figure 4-9: DMS Underway

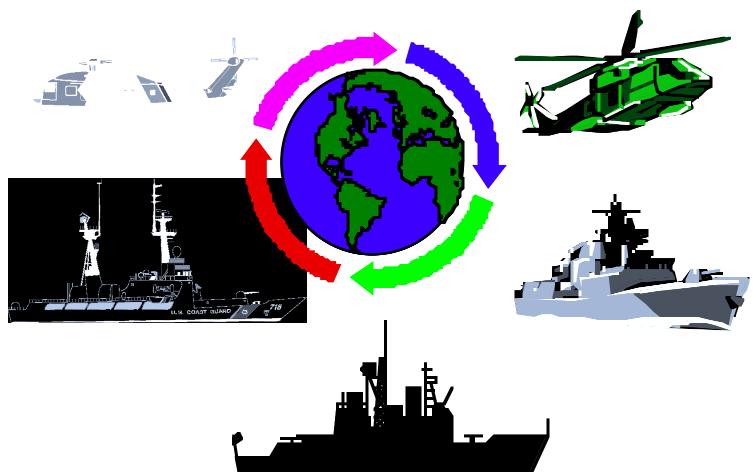
- **<u>DMS and the Coast Guard:</u>** Several classes of Coast Guard vessels have the ability to exchange organizational record messaging electronically. These range from 399ft Icebreakers down to 110ft Patrol Boats. The larger cutters (270ft and above) use NAVMACS or NAVMACS II as their messaging system. They send and receive messages via the Navy NCTAMS, which provides the interface to AUTODIN.

  The Coast Guard interface to AUTODIN is provided by one of 18 Message Distribution Terminal (MDT) sites. For vessels under 270 feet, messages are routed through Coast Guard Communication Stations (COMMSTAs). The COMMSTAs provide the shore-based interface to the CGDN and SDN for unclassified and GENSER classified messages, respectively. Messages are delivered via UHF SATCOM or HF, depending on the size of the vessel. Smaller ships typically use HF RATT or the polled HFDL

Specific plans for the implementation of DMS, in a tactical environment, have not yet been formulated. The Coast Guard is working with the Navy DMS Tactical Working Group to design this architecture. At a minimum, message format and protocol conversion will need to be provided by the implementation of an MFI at the COMMSTAs. The COMMSTAs will continue to provide the interface to the CGDN.

The Coast Guard is in the process of automating their tactical communications by installing a T-1 network between the COMMSTAs. By FY99, all COMMSTAs will be remoted to the two Communication Area Master Stations (CAMS).

4.4 DoD Interoperability



The Coast Guard operates in a multi-mission environment which includes increasing requirements to participate in combined operations with the Department of Defense (DoD). In a world of rapidly changing technology, the Coast Guard must be increasingly adaptable, flexible, and responsive to change. Coast Guard forces have taken this challenge to heart and are responding in a superb fashion. Streamlining efforts have produced a lean, efficient, and effective organization. One factor critical to continued mission success, improved readiness, and enhanced quality of life for mobile forces will be the ability to share information, seamlessly, and in real-time or near real-time through flexible, adaptable, interoperable communications systems.

The current communications systems will not meet the throughput demands of the future. Communication systems can no longer be developed, procured, and fielded to meet specific fleet operational requirements, and implemented in a "stovepipe" fashion. However, taking a "Network of Networks" approach will lead to the fielding of communications assets that are inter-operable and flexible enough to meet the throughput demands of today's and tomorrow's Coast Guard operational units. The future communication system must incorporate open systems architecture (OSA), and "plug and play" modularity to be easily reconfigurable and upgradable.

This Section of the TCP explores several technologies that are applicable to Coast Guard communications interoperability with the Department of Defense. For the purpose of this Section of the TCP, these technologies have been analyzed at a high level to determine their potential for addressing current and future requirements, and their impacts on the Coast Guard's future telecommunications architecture.

4.4.1 Technologies

A combination of several current and emerging telecommunications technologies, each with unique capabilities, will be used in conjunction with one another to make up the future "Network of Networks". This all encompassing system will move all types of information seamlessly from place to place within the Coast Guard and also interface with other government agencies through direct circuits and network gateways. Some of these technologies are already in place and in operation, some will be the result of future procurements, and others will be provided to the Coast Guard by DoD to promote interoperability, and support the requirement for Coast Guard/Navy compatibility.

The "network" will provide several basic services. These include record message traffic delivery, electronic mail, and providing the transport medium for mission essential applications.

4.4.1.1 Dedicated Department of Defense Networks

Until security services to support the transport of sensitive information over commercial carrier services becomes viable, dedicated networks will continue to be important resources. The evolution of the Defense Data Network into the Defense Information System Network (DISN) and the Integrated Tactical/Strategic Data Network into a worldwide information transfer infrastructure supporting National Defense Command, Control, Communications, Computers, and Intelligence (C4I) requirements as well as Corporate Information Management and Defense Information System areas is well underway. The DISN focuses on providing integration of current systems, encompassing the period through the mid-1990s, and providing long-haul transmission services as well as a data transport service. The DISN includes point-to-point transmission, switched data services, video teleconferencing, etc. (C4I Interoperability Assessment Pg. 17)

The Coast Guard will directly interface with the DISN to obtain DoD long-haul data transmission services, and to maintain required compatibility with the Navy. This will be accomplished in conjunction with the planned implementation of the Defense Message System (DMS), which replaces the current world-wide Automatic Digital Network (AUTODIN). Interface (or gateway) locations have not yet been determined.

4.4.1.2 Defense Message System (DMS)

DMS provides secure, accountable and reliable messaging services, fully integrated with a global DoD directory service, based on Joint Staff validated requirements. It has a robust set of services that will work writer-to-reader, desktop-to-desktop within DoD and externally. With these capabilities, you will be able to access global directories from anywhere in the world, complete with addressing, security, and user capabilities information for all of the messages you compose and receive at your desktop.

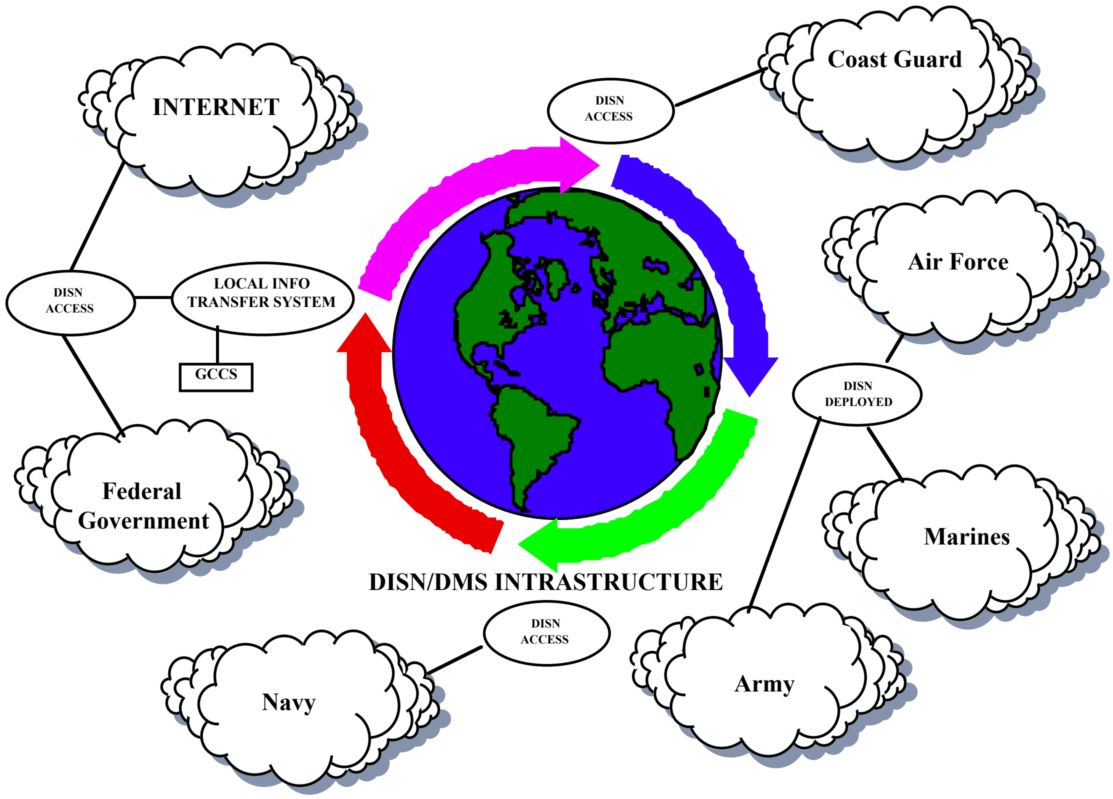


Figure 4-10: Defense Message System (DMS)

DMS will be implemented with commercial-off-the-shelf (COTS) products to be based on a set of international, open-system standards that provide full interoperability from writer-to-reader.

Additionally, DMS will provide interfaces to and interoperability with other federal agencies, our Allies, the commercial sector and the public. This is being done using a standards-based suite of products that ensure writer-to-reader messaging services and global directory capabilities, without the use of gateways.

The following DMS training courses are available through DISA's contract with LORAL Federal Systems. They are designed to be taught at either a Government facility or by the contractor, for individual users or for/by Government Instructors:

- Basic User Training Course
- Operating System Administrator (OSA) Course
- Message Handling System (MHS) System Administrator Course
- Directory System Administrator (DSA) Course
- Management Workstation Product (MWS) Course

Users can also order any of the above training courses from commercial vendors off the DMS contract. The Basic User Training Course can be taught to a maximum of 25 students per class.

All other training courses are taught to a maximum of 10 students per class. The number of DMS gateways will directly affect the amount of DMS training that is required.

Costs and architecture for Coast Guard-wide DMS implementation are not yet fully developed. However, the Coast Guard is well positioned to effectively integrate DMS and its desktop-to-desktop capabilities building upon the foundation of the Coast Guard Standard Workstation III transition currently in progress.

(Ref: http://www.spawar.navy.mil/pmw-176)

A government-wide e-mail Program Management Office (PMO) has been established within the General Services Administration (GSA) to support the development of service that appears to the user to be a single, unified electronic postal system. This system will offer robust and trustworthy capabilities with legally-sufficient controls for moving all forms of electronic information among employees at all levels of government, and with the public.

Like the nation's telephone network, government-wide e-mail needs to be affordable, efficient, accessible, easy-to-use, reliable, cost-effective, and supported by an effective directory service. The DMS program is being designed to support the exchange of e-mail with the government-wide e-mail system, and will allow an interchange of e-mail between DMS and commercial/other government agency (OGA) domains.

The DMS program is described in the "U.S. Coast Guard Information Security" document in the section entitled "FORTEZZA and DMS." Both programs will share many features and structures in common, but e-mail exchange within the DoD DMS community may be segregated.

There are many considerations to adoption of an e-mail strategy, including infrastructure requirements, interoperability limitations, translation gateways, maintenance of records, user accountability, firewall configuration, public access, organizational release requirements and procedures, use in the tactical environment, and many others.

The DMS program is implementing multi-function interpreters (MFIs), that provide protocol translation for interoperability with legacy systems during the transition and with non-DMS compliant systems external to the DoD after achievement of the objective DMS system.

The specifications for DMS do not clearly describe how DMS users can communicate with external or legacy users who are not provided with FORTEZZA cards.

No formal training, on this technology, is being offered at this time.

(Ref: C4I Interoperability Assessment, Pg. 18-19)

4.4.1.3 Military Satellite Communications (MILSATCOM)

Coast Guard assets have no cost access to certain MILSATCOM systems based on unique operational requirements and interoperability needs with the U.S. Navy. The Navy UHF Fleet

Satellite Communications (FLTSATCOM) system consists of leased and Navy owned satellites that provide world-wide communications connectivity with naval ships and airborne platforms. The FLTSATCOM system comprises space, earth, and control segments. Space and earth segments consist of satellites, earth terminals, subscribers, and subsystems. FLTSATCOM subsystems most commonly used by Coast Guard units are:

- Officer-in-Tactical Command Information Exchange Sub-system (OTCIXS) which provides a two-way link to support inter- and intra-battle group over-the-horizon targeting tactical command and control data communications in a near-real-time (1-15 minutes) environment. It provides a gateway to the SIPRNET which allows bi-directional tactical data links between shore commands and OTCIXS equipped units. OTCIXS is currently used by 378s and 270s, and is being installed on 210s and Transportable Communications Centrals (TCCs).

- Common User Digital Information Exchange Subsystem (CUDIXS)/Naval Modular Automated Communications Sub-system (NAVMACS) provides a 2400 baud full duplex interface over a satellite link with mobile platforms. NAVMACS provides up to four channels of fleet broadcast input, a subscriber interface to CUDIXS and other on-line message functionality. NAVMACS on Coast Guard cutters is configured with Coast Guard Standard Workstation (CGSW) equipment and supported by the Shipboard Telecommunications Computer System (STCS).

- UHF Demand Assign Multi-Access (DAMA) Sub-system provides users with increased communications capacity and reliability over dedicated access on the FLTSATCOM satellites. DAMA is capable of multiplexing secure voice, record message, and data sub-systems onto a single 24 kHz satellite channel. WAGBs, WHECs, and 270s have DAMA, while 210s and the TCCs are being upgraded.

Military Strategic, Tactical, and Relay (MILSTAR) is a military satellite communication (MILSATCOM) system that provides highly robust, secure, and survivable communications among fixed-site, mobile, and portable terminals. Operating primarily in the extremely high frequency (EHF) and super high frequency (SHF) bands, MILSTAR satisfies the US military's hard-core communications requirements with worldwide, antijam, low probability of intercept (LPI), and low probability of detection (LDP) communications services.

In the MILSTAR EHF and SHF bands, small antenna apertures produce narrow beams, which are difficult to jam, with high transmit and receive gain.

The MILSTAR payloads perform extensive on-board processing of the uplink and downlink waveforms for efficient on-orbit resource use and maximum antijam performance. On-board signal processing ensures full interoperability among the military services and other users who operate terminals on land, sea, and in the air.

Often described as a switchboard in the sky, the MILSTAR payloads have on-board computers that perform communications resource control. MILSTAR responds directly to service requests from user terminals without satellite operator intervention, providing point-to-point communications and network services on a priority basis.

The MILSTAR payloads can reconfigure in real-time as users' connectivity needs change, providing the dynamic communication networks that highly mobile tactical warfighters require.

Worldwide connectivity is established using space-to-space satellite crosslinks. Crosslinking allows user communication networks to extend around the globe without retransmission, through intermediate ground stations. Crosslinking also provides worldwide command and telemetry access to every MILSTAR satellite.

The entire MILSTAR constellation can be operated through the crosslinks from a single CONUS-based mission control station; potentially vulnerable foreign control sites are not required.

Each MILSTAR satellite has a mass of approximately 10,000 pounds and produces nearly 5000 Watts of solar array power. The first two MILSTAR satellites (called MILSTAR I) have a low data rate (LDR) payload. The third and subsequent vehicles (MILSTAR II) feature a medium data rate (MDR) payload. The completed MILSTAR II constellation will consist of four satellites in near-geostationary equatorial orbits.

- **MILSTAR Highlights**:
  - Global coverage via Earth coverage, agile, and steerable antennas;
  - Automatic terminal logon and network setup procedures;
  - Assured global connectivity via onboard router, processor, and crosslinks;
  - CINC-controlled resource allocation for dynamically changing situations;
  - Flexible communication services:
    - Point-to-point
    - Conference network
    - Broadcast
    - Voice, data, imagery, and video teleconferencing capabilities;
  - Throughput rates to simultaneously support Navy battlegroups, shore stations, and Naval independent operators;
  - LPI/LPD to protect terminal assets and special operations;
  - UHF capability and EHF/UHF crossbanding for interconnecting with AFSATCOM and fleet broadcast terminals;
  - Interoperable waveforms and data rates;
  - Robust, antijam, waveforms;

- Nulling antennas for in-beam jamming protection; and
- Communications Security (COMSEC)/Transmission Security (TRANSEC) protection with over-the-air rekey (OTAR) capability/specifications.

No significant increase in current training requirements is expected.

(POC: Steve Johnson at msl@leonardo.jpl.nasa.gov)

4.4.1.4 Electronic Data Interchange

Electronic Data Interchange (EDI) efforts are intended to extend the benefit of information systems applications to transactions conducted between autonomous activities. Information and communications technology that is needed to build inter-organizational systems has been available since the late 1960s. However, the relatively slow adoption of inter-organizational systems suggests that they have to be viewed not primarily as technically-driven, but rather as business-driven systems. Early examples are computer-reservation systems in the airline industry, inter-bank systems for funds transfers, and ordering systems in the auto industry. They underscore the purpose of inter-organizational systems which is to facilitate official transactions among cooperating activities.

Inter-organizational transactions improve the speed, ease, and quality of information transfer, and extend the concepts and goals of office automation into the inter-organizational realm. EDI is the inter-organizational, electronic exchange of standardized messages among applications. *EDI enables organizations to exchange any structured document in a standard format among their applications with little or no human intervention.*

A crucial part of EDI is the message standard. Standardized messages are the precondition for an automated exchange and interpretation of the message contents. In order to facilitate international trade and commerce, the United Nations has taken over the responsibility to develop a message standard for EDI known as Electronic Data Interchange for Administration, Commerce, and Transport (EDIFACT).

Although the development of a global business language (i.e., message syntax that can be used independent of hardware and software, is a long and tedious process, the advantages over bilateral, sectoral or national standards are considerable. The goal of the implementation of EDI based on EDIFACT is to conduct entire business transactions with multiple partners, such as suppliers, customers, service providers, peer agencies, banks, etc., based on a single technology and a single standard.

According to the philosophy of the ISO/Open System Interconnection (ISO/OSI) model of communication that distinguishes different functional layers and in order to avoid unnecessary rigidities, EDIFACT covers only the message syntax. How the messages are actually transferred among the partners depends on the communication technology that is available and on their needs in terms of bandwidth, security, and level of service. E-mail exchange standards, such as INTERNET’s Simple Message Transport Protocol (SMTP) and CCITT X.400 are ideal candidates for a low cost transmission of EDIFACT messages. Other standards and telecommunication services are available and are offered by the National Post, Telephone, and Telegraph (PTT) or private Value-Added Network (VAN) service providers.

Like many other technologies, EDI has been accepted more slowly than expected. EDI has been perceived as too complicated, activities did not know how to integrate EDI into their applications, standard messages were not available, and the number of potential partners was relatively low. However, this situation has changed significantly. Throughout the world, the number of activities that use EDI has risen. Large companies demand that their business partners be able to accept EDI messages (and in many cases assist them in setting-up the requisite technology). Public sector initiatives, like the Clinton administration's Electronic Commerce for Acquisition initiative will accelerate acceptance of EDI.

Three perspectives can be distinguished for electronic commerce on the INTERNET and EDI:

- The INTERNET can be used to transmit EDI messages;
- Standards for the inclusion of EDIFACT messages as bodies of e-mails sent via the INTERNET have been developed. Transmission costs are significantly lower than traditional communication via PTTs or VANs, but reliability and security are a concern of many potential users;
- EDI application can be built upon the World Wide Web (WWW) providing an easy to use interface for the customer, and generating EDIFACT messages (e.g., orders or payment orders) transparently. The advantage of this solution, is that the EDIFACT application actually (because of the underlying client-server architecture) resides at the provider's system, the customer only needs a WWW browser and INTERNET access.

EDI and WWW services can be seen as complimentary: while EDI focuses on standardized business transactions, WWW applications focus on the transmission of multimedia information.

No significant increase in current training requirements is expected.

(Ref: C4I Interoperability Assessment Pg. 21-24)

4.4.1.5 Defense Satellite Communications System (DSCS)

The Defense Satellite Communications Systems (DSCS) is an important part of the comprehensive plan to support interoperability of globally distributed military users.

Currently, two Phase II and eight Phase III DSCS satellites orbit the earth at an altitude of more than 23,000 miles. DSCS III also carries a single channel transponder used for disseminating emergency action and force direction messages to nuclear capable forces. Each satellite utilizes six super high frequency transponder channels capable of providing worldwide secure voice and high rate data communications.

The system is used for high priority communication, such as the exchange of wartime information between defense officials and battlefield commanders. The military also uses DSCS to transmit space operations and early warning data to various systems and users.

The first of the operational DSCS II satellites was launched in 1971. Their two-dish antennas

concentrate electronic beams on small areas of the Earth's surface, but have limited adaptability in comparison to the newer DSCS III.

The Air Force began launching the more advanced DSCS IIIs in 1982. The system is built with single, multiple-beam antennas that provide more flexible coverage than its predecessors. The single steerable dish antenna provides an increased power spot beam which can be tailored to suit the needs of different size user terminals. DSCS III satellites can resist jamming and are expected to operate twice as long as DSCS IIs.

DSCS users operate on the ground, at sea, or in the air. A special-purpose (AFSATCOM) single channel transponder is also on board the DSCS III satellite. Members of Air Force Space Command units, the 50th Space Wing's 3rd Space Operations Squadron at Falcon Air Force Base, Colo., and 5th Space Operations Squadron at Onizuka Air Force Station, Calif., provide command and control for all DSCS systems.

(Ref: http://www.laafb.af.mil./smc/mc/dscs.html)

(Ref: http://www.disa.mil/org/disad321.html)

4.4.1.6 Global Broadcast System (GBS)

The GBS will "push" a high volume of intelligence, weather, and other information to widely dispersed, low cost receive terminals, similar to the commercial DBS. The system will include a capability for users to request or "pull" specific pieces of information. These requests will be processed by an information management center where each will be prioritized, the desired information requested, and then scheduled for transmission.

Acting in response to a request from the Space and Naval Warfare Systems Command, NRaD has submitted a proposal for an X-band Global Broadcast Service (GBS) demonstration system. This system would use DSCS to demonstrate a way to provide GBS service to the military using government owned space assets and current terminal hardware. The plan is to demonstrate the utility of such a system by moving some of the current UHF and SHF traffic onto the X-band GBS broadcast. This would fit into the proposed GBS concept by providing the “intelligent push” type data, and also fits the requirements stated in the GBS Mission Needs Statement. The X-band system would provide a limited data rate Navy Broadcast capability. It would require modified SHF terminal hardware.

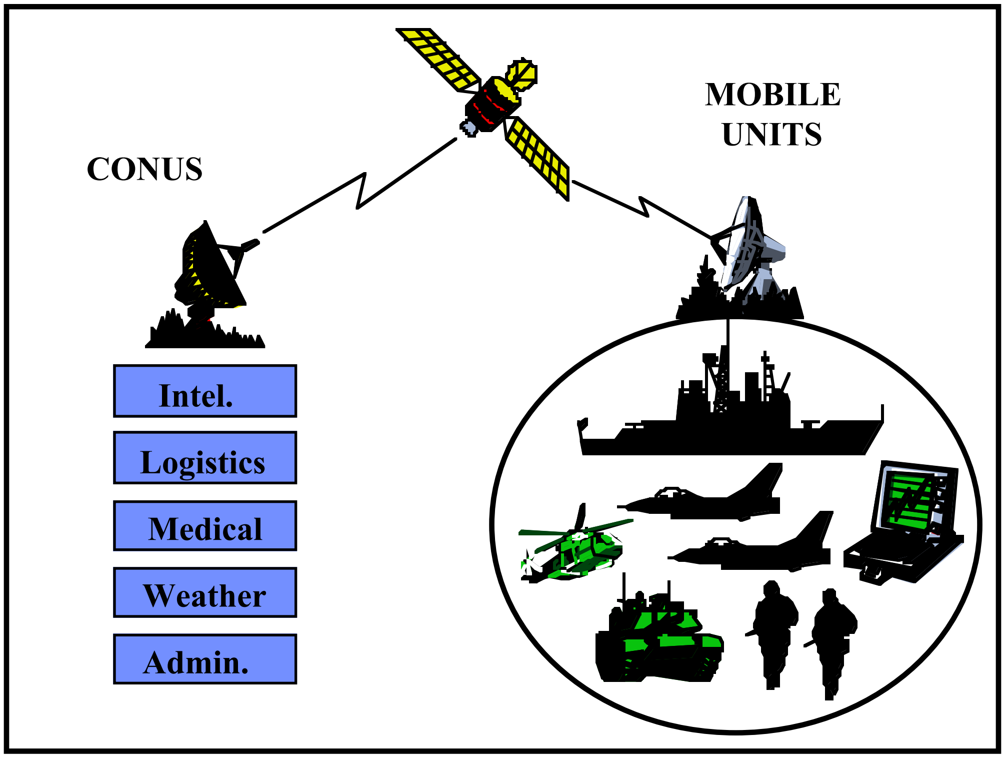


Figure 4-11: Interoperable Global Broadcast System

The concept is to put a GBS link on the DSCS immediately. This would provide a system to develop and test a concept of operations. It would provide a way to test network protocols and determine which services should be provided. The net would be moved to the GBS when the full satellite system is fielded. The current Army, Air Force, Marine Corp., and Navy SHF terminals would be used. The broadcast would be truly Joint.

In 1994, the Navy and Marine Corp. conducted a Joint Warfare Interoperability Demonstration (JWID-94). That demonstration was followed by JWID-95. There are significant differences between JWID-95 and other military exercises. The understood purpose of JWID-95 is to push the state-of-the-art. In exercises there is less impetus to try new and innovative concepts because there is pressure to ensure that everything works as planned. In JWID-94, there were mostly standalone demonstrations. In JWID-95, there was an increasing emphasis to integrate the C4I demonstrations to enhance total system performance. The objective is not to automate existing systems, but to develop new approaches to improve C4I for the warrior. As such, JWID-95 was an excellent opportunity to show the military operators the capability that this system can bring to the warfighter. The GBS demonstration that was done during JWID-95 transmitted data over the commercial DBS satellite at the 23Mbps data rate. Several types of data, mostly tactical intelligence, were successfully transmitted.

Hughes builds the UHF Follow-On (UFO) satellites, which share a lot of the common spacecraft bus hardware with the DBS satellites. The intent is to modify Flights 8, 9, and 10 of the UFO program to include the high power wideband transponder for the GBS application. The first of these is scheduled to fly late 97 or early 98. The operational concept is to have some bandwidth set aside for general broadcast (producer-push) similar to Tactical Related Applications Broadcast and Fleet Broadcast (the first two world-wide broadcast systems) and some for query services (user-pull) response. The actual data format is being defined as is the frequency of the broadcast with SHF (X-band) favored over the Ka-band (20gHz). The JWID-95 data format was ATM and straight digital video in the commercial DBS format.

The GBS user hardware suite includes a 1 meter dish, a commercial receiver, a rate buffer module that provides the data interface to a user's computer equipment, and a HG-194 cryptographic unit. The cost for this hardware suite is roughly $40,000.

(Ref: C4I Interoperability Assessment Pg. 101-102)

4.4.1.7 Cellular Telephone

Communication across Circuit-Switched Cellular Networks involves the use of a cellular phone for voice communications or attaching a wireless computer modem to a cellular phone for data communications. Connection via an air-link through a nearby cell, then through the regional switch and ultimately through the telephone network to another computer is continuous until the link terminates when one participant hangs up.

The existing analog cellular network has a huge installed infrastructure providing "seamless" (since 1992) coverage, but only moderate speed (slower than spread-spectrum technology or Cellular Digital Packet Data (CDPD)) and high cost (more expensive, for example, than spread-spectrum or satellite transmission). Transmission of data is billed by the minute rather than by the character or kilobyte, in some cases yielding up to ten times the price of other wireless services to transmit identical quantities of data. The service offers access to the information services, like INTERNET, America Online, and CompuServe.

For 35 years, the wireless communications industry has been inching up the spectrum, shifting slowly from long and strong wavelengths toward wide and weak bands of shorter wavelengths. Transportable phone services have moved from the 1950s radio systems, using low FM frequencies near 100MHz, to the 1960s spectrum band of 450MHz, to the current cellular band of 900MHz, accommodating more than 23 million cellular subscribers in the U.S. During the 1990s, this trend will accelerate sharply. Accommodating hundreds of millions of users around the world, cellular communications will turn digital, leap up the spectrum, and may even move into video.

As stated in Section 4.2 (Mobile Communications), the CONDOR product from Qualcomm Inc. will have a potential impact on the Coast Guard. CONDOR is a secure, multi-mode hand-held cellular device that supports Code Division Multiple Access (CDMA) when available, and Advanced Mobile Phone Service (AMPS) and Time Division Multiple Access (TDMA) when CDMA service is not available. The CONDOR is also capable of a broadcast mode that can serve in place of land mobile radio (LMR) capability.

The Federal Bureau of Investigation (FBI), the Drug Enforcement Agency (DEA), and Joint Chiefs of Staff are very interested in CONDOR, and together with the National Security Agency (NSA) are making a significant investment in secure CDMA technology.

The CONDOR units use the FORTEZZA-plus card to support STU-III interaction. Future versions of the FORTEZZA-plus card (known as the FACET encryption card), due to be released in late 1997, is planned to be integrated into the CONDOR product. The FACET card will allow for Type-1 encryption over networks. This same standard adapter on the CONDOR unit supports any of several GPS adapters. The Federal government (in a variety of agencies) is expected to buy up to 1.4 million CONDOR units. Of these units, 350-450 thousand are expected to be Data Encryption Standard (DES) protected and 10-15 thousand Type-1 protected. It is also expected that state and local governments will purchase 4-5 million units.

This system is designed to be used as a vital, secure communication system in Joint Services and covert activities. CONDOR may be poised to be extremely attractive to Coast Guard planners. A fully functional CONDOR, operating according to current designs, could provide the Coast Guard with an inexpensive automatic position location capability, with an accuracy of 100 meters, using Globalstar, for emergency situations. This may provide the Coast Guard with DoD and OGA interoperability in support of Search and Rescue, Law Enforcement, and disaster response operations. The estimated cost for the instrument is targeted for $100-125 each.

Cellular technology may provide a high level of interoperability between the Coast Guard and DoD for both voice and data communications. Cellular telephone capabilities may be especially useful for communicating across agency boundaries during emergency or disaster operations (i.e., natural disaster, hurricane, flood, etc.), and simulated and actual wartime operations.

(Ref: C4I Technology Assessment, Pg. 40-41)

4.4.1.8 American Mobile Satellite Corporation (AMSC)

The first U. S. based mobile satellite service provider was American Mobile Satellite Corporation (AMSC). They currently have one satellite in orbit and authorization for two more. The operational unit has 2000 6kHz voice grade channels. AMSC’s partner, Telesat Mobile Inc. of Canada was due to launch an identical satellite in early 1996. With that addition, the two companies will provide redundancy for each other in the space segment of their systems.

The AMSC mobile digital telephone service is called “Skycell Satellite Roaming Service” or “Skycell”. Customers will access Skycell through dual mode satellite/cellular telephones that will be offered by two commercial vendors. These mobile telephones will first seek an available cellular system. In the absence of cellular coverage, the call will be automatically processed over AMSC’s satellite system. In this case, the signal will be sent up to the satellite, then down through one of AMSC’s primary gateway hubs. The hub will process the call and connect it to the long distance network which will deliver it to the local public switched telephone network (PSTN). The local network will then forward the call on to it’s destination. Skycell service complements the current terrestrial cellular system in the U.S. Skycell features include:

- Directory Assistance;
- Operator Assistance;
- One Touch 911;
- Call Forwarding;
- Call Waiting;
- Three Party Calling;
- Conference Calling;
- No Answer Transfer;
- Call Restriction; and
- Voice Mail.

In addition to the dual mode satellite/cellular telephone service, AMSC will introduce a series of satellite only mobile telephone products to serve a variety of market needs. Included in this market is corporate and general aviation, private and commercial ships, and *law enforcement agencies*. This product serves those customers who need telephone communications wherever they go.

AMSC has stated that they will lease satellite channels (power and bandwidth) to the U.S. Government for use in private networks on a yearly basis. They have stated that they are willing to negotiate the number of channels as well as the length of lease. Prices will be negotiated based on lease period, but a price of $200,000 per year for one 6kHz channel was quoted in early October 1995. The same terminal equipment will be used on leased channels as with the Skycell option.

- **Terminal Equipment:** Terminal equipment will be available in the form of small, lightweight, mobile satellite/cellular systems and the satellite-only mobile telephone systems. Additionally, fixed sight terminals will be available. Available terminal equipment provides voice, secure voice (using STU-III), facsimile, and a full duplex personal computer data port using Hayes V-24 modem commands. These services are available at data rates of 2.4kbps and 4.8kbps. Prices for this service (Skycell) are projected to be $1.49 per minute with a $25.00 per month access fee.

AMSC's satellite/cellular telephone service looks to be an attractive addition to the telephone services now available from cellular providers, and this is evidenced by the extensive Government involvement with AMSC. It is also an attractive alternative to the more costly INMARSAT system for cases where the user stays within the AMSC satellite footprint. AMSC satellite spot beams cover all of the continental U.S. and Canada with coverage out to 200 miles offshore, Hawaii, and the entire Caribbean area. Both terminal cost and the per minute and monthly access fees are less expensive than INMARSAT.

AMSC provides similar capability to INMARSAT, but with a maximum data rate of 4.8kbps. One drawback is that both AMSC and INMARSAT equipment would need to be retained/maintained because they are incompatible systems. Both of these systems have a potential to meet DoD interoperability requirements by providing a common, reliable, rapid, and secure system for inter-agency voice and data communications.

(Ref: C4I Interoperability Assessment Pg. 92-95)

4.4.1.9 International Maritime Satellite (INMARSAT)

INMARSAT offers the following service types:

- INMARSAT-A: Supports high-quality direct-dial telephone, telex, facsimile, and data services;

- INMARSAT-B: Provides a similar range of services to INMARSAT-A, but, because it is based on modern digital telecommunications technologies, INMARSAT-B terminals are smaller, lighter, and cheaper to buy and incur lower user charges;

- INMARSAT-M: Terminals are the size of a briefcase. Provides direct-dial telephone, facsimile or 2.4kbps data connections. Maritime versions are fitted with tracking antennas with radomes about one eighth the volume of their bigger, more capable INMARSAT-A/B brothers. Terminal and user charges are also considerably less than those for the larger systems;

- INMARSAT-C: Lightweight, compact, and comes with omni-directional antenna systems. The terminals come in fixed, mobile, transportable, maritime, and aeronautical versions. INMARSAT-C supports two-way, store-and-forward message, text, or data reporting communications at a data rate of 600bps. INMARSAT-C supports two-way global messaging, fax, and e-mail. Services include: position and data reporting, weather forecasts, and electronic chart corrections; and

- INMARSAT-Aero: Provides store-and-forward text or data messages; real-time, data-only communications; and multiple-channel, flight-deck voice telephony.

INMARSAT is developing a revolutionary system called INMARSAT-P, which will facilitate the development of a global handheld satellite phone system, and allow direct satellite access from the one portable phone anywhere in the world. Current satellite telecommunications systems use geostationary satellites circling the earth 25,000 miles above the equator, once every 24 hours, the same as the earth's own orbit. INMARSAT-P will use a system of ten satellites which will orbit the earth once every 6 hours at a height of about 6,210 miles. Because these satellites are angled from the equator, telephoning will be possible from remote areas, such as the North and South Polar regions. The portable phone will be connected to the nearest satellite connecting station via satellite. The call is then connected to existing public networks and the receiving party's phone.

The range of products and services which will be supported by the INMARSAT-P system include a dual-mode cellular/satellite handheld phone supported by network integration with cellular systems. This will enable a caller to access terrestrial cellular links, when they are available, and satellite links, when terrestrial links are not available. Twelve access nodes will form a network to link INMARSAT-P satellite phone callers to public terrestrial and cellular networks. Based on the expenditures and backing to date, INMARSAT-P will be a major player in the LEOS market. (Ref: C4I Interoperability Assessment Pg. 116-118)

Table 4-10: INMARSAT-P Satellite System Information

Service Types:	Voice, Data, Facsimile, Paging
Data Rates:	4.8kbps voice, 2.4kbps data
Voice Circuits per Satellite:	4500
System Cost:	$2.6B(U.S.)
User Terminal Cost:	approximately $1000
Dual Mode User Terminal:	Yes (regular cellular and satellite)
Handheld User Terminal:	Yes
Operational Startup:	the year 2000
Satellite Lifetime:	10 years
Call Charge Rates:	$1-$2 per minute

Ref: http://www.worldserver.pipex.com/inmarsat

4.4.1.10 High Frequency (HF) Radio Communications

High frequency communications was the backbone of Coast Guard ship-shore record and tactical communications for many years. With the advent of radioteletype and data-link technology, HF provided a somewhat reliable means of passing operational and administrative traffic between mobile units and shore commands. However, many Coast Guard mission areas suffer from the lack of communications interoperability with the Navy, and potentially with international agencies which are procuring similar equipments. The Navy’s HF improvement process has inserted new HF technology into the command and control systems, including HF Automatic Link Establishment (ALE), HF High Speed Fleet Broadcast, and HF radio systems with fast tuning capabilities.

Both the Navy and the Coast Guard have documented (Data/Communications System Technical Operational Requirement, dated 1 April 1993) that the WMECs do not have the communications capability to operate effectively together. Specifically, the 210ft cutters do not have the capacity to handle large amounts of record traffic, with little or no capability of communicating in a real-time or near real-time basis. Interoperability among Coast Guard units, other law enforcement units, and DoD units is limited.

One of the most important operational requirement is for Coast Guard cutters to be interoperable with Navy ships. Cutters receiving interoperable communications capabilities must maintain interoperability with other Coast Guard units not operating with the Navy. The implications of the interoperability requirements are significant for the entire Coast Guard C4I infrastructure. The CAMS/COMMSTAs would require upgrading to provide the same capabilities that the cutters operating with the Navy have in terms of protocols, modem standards, data/message processing, data rates, and transmission security. This includes:

- Medium to high data rate serial tone modems (STMs);
- Message processing systems interoperable with Navy HF message delivery systems;
- Fast tuning, rapid frequency shift radios with ALE controllers;
- Secure voice and message communications;
- Common crypto and crypto keylists; and
- Real-time data link for command and control of own units in local and multi-national operations.

In joint or mutually supporting operations, HF communications interoperability is critical. Communications circuits must reach all users of the service being supported. To ensure interoperability, all services must use and conform to the same standards in hardware design, software application, and transmission protocols. Some of the key standards applicable to HF communications include:

- MIL-STD-188-110A - Interoperability and Performance Standards for Data Modems;
- MIL-STD-188-141A - Interoperability and Performance Standards for Medium and High Frequency Radio Equipment;
- MIL-STD-188-203-1A - Interoperability and Performance Standards for Tactical Digital Information Link; and
- MIL-STD-188-331 - Video Teleconferencing.

High data rate modems are rapidly expanding the throughput rates available on HF. Until the recent past, 75bps HF circuits were considered the “norm”. With the move to Serial Tone Modems (STMs), higher data rates were made possible due to their ability to overcome the fading problems experienced with earlier multi-tone modems. Current technology is pushing STMs to 4.8kbps with 9.6kbps expected in the near future. Technology demonstrations have shown that HF is capable of supporting data rates as high as 75kbps using satellite modems. This data rate is approaching rates that will support video transmission with the proper compression/de-compression algorithms.

Cost is a programmatic issue, but must be addressed to get the most capability for a given amount of money available. In HF communications one of the ways costs are being addressed is on a per circuit basis. This appears to be a reasonable approach, provided the definition of a circuit is clear (i.e., does it include racking, installation, cabling, shock mounts, etc.). Reasonable values appear to be $60,000-120,000 per circuit less antenna, installed. The cost depends upon the technology selected and does not include such items as old equipment and cable removal, space reconfiguration, etc.

HF communications technology has made significant advances in the past ten years, providing new capabilities to systems being fielded now and showing promise for new systems to be fielded over the next five years. As a result of this new technology insertion, HF communications have again become a viable path for long-haul communications, backing up SATCOM where they overlap and providing a reliable communications path in areas where there is limited satellite coverage.

One of the highest priorities in the National strategy is to conduct all military operations as Joint operations, if only the U.S. is involved, or as combined operations, if allied or coalition forces are involved. In all cases, interoperability is the key word. The impact on Coast Guard HF is significant for the WHECs and larger WMECs that are nationalized to Navy operational control in certain war scenarios. The interoperability requirement also has an impact on all cutters and boats that could find themselves in any operation involving other services and agencies. Several HF capabilities which may meet interoperability requirements are listed below:

- Serial Tone Modems (STMs) — standard for record message traffic, except the High Speed Fleet Broadcast (HSFB). Without high speed STMs, cutters will not be able to interact with the Navy.

- HF E-mail — includes STM and KG-84 crypto interfaced to an HF radio; rapidly becoming the medium of choice for non-tactical information exchange intra-force and between ships and shore facilities;

- HF Video — PC based and can use any media, including SATCOM and HF. HF can currently support freeze-frame and slow video, graphics and interactive real-time graphics markup, facsimile, and voice support. Although currently there is no direct impact on the Coast Guard from this Navy program, in the future it could become a standard way of joint planning. If this is the case, the Coast Guard could be hampered in future operations.

- Portable RF Integrated Network (PRIN) — provides adaptive throughput to counter jamming and interference and to provide error free data. PRIN uses ALE to establish connectivity and SURENET code-combining to obtain Automated Link Maintenance. The Navy may implement PRIN. This would have an impact on Coast Guard interoperability, since a non-PRIN platform could not communicate on PRIN supported services.

(Ref: C4I Interoperability Assessment, Pg. 132-169)

There are a number of issues associated with HF usage in the Coast Guard that may require attention. This includes High Frequency Data Link (HFDL) interoperability, where the Navy's HF E-mail system could meet Coast Guard requirements. However, the Coast Guard has expressed continued concern about using an X.25 based protocol to replace HFDL, because of cutters not being able to hear each other "stepping" on each other's transmission due to HF skyway "shadowing". (This problem could be overcome if HF E-mail is used in conjunction with an ALE controller.) The advantage of this system is that it uses recognized standards, and the system configuration allows it to be easily upgraded by changing PC cards and software rather than system hardware.

4.4.1.11 Digital Modular Radio System:

Digital Modular Radio (DMR) System will satisfy tactical communications requirements in the High Frequency (HF), Very High Frequency (VHF), and Ultra High Frequency (UHF) ranges. DMR will reduce the cost of acquiring and upgrading communications systems and will increase tactical flexibility. The DMR System will migrate from stand-alone, "stovepipe" terminal systems to a modular radio comprised of flexible, software configurable hardware modules. The DMR controller will be able to command any set of these common hardware modules to perform the function of any of the separate radios that now operate in these frequency ranges. Employing common hardware modules, standards, and software will reduce the need for multiple procurements of unique terminal systems, each with their own life cycle support. This emphasis on open hardware and software architecture will reduce the cost of acquiring, fielding, maintaining, and supporting this system.

DMR will permit the tactical commander to reconfigure RF assets in accordance with changing mission needs. Each hardware module in the DMR System will be configurable and can tune and perform related functions within multiple frequency spectrums. DMR will be compatible with Automated Digital Network System (ADNS) for network control and monitoring capabilities.

In addition, the DMR System will field integrated, multiband antennas, such as the Multifunction Electromagnetic Radiating System (MERS), that will reduce topside space and weight, and will lessen ship radar cross section (RCS). In short, DMR will provide affordable, flexible, interoperable, demand adaptive communications.

(Ref: http://www.spawar.navy.mil/pmw176/swartc16.htm)

4.4.1.12 Integrated Terminal Program:

Integrated Terminal Program (ITP) will provide flexible and responsive subsystems and terminal equipment that will enable protected narrowband and wideband communications connectivity. ITP will satisfy communications requirements in the Super High Frequency (SHF), Extremely High Frequency (EHF), and Commercial SATCOM frequency bands.

This program will field a collection of military and commercial products that will evolve to further increased communications connectivity and Joint interoperability. ITP will leverage commercial terminal systems and services, such as C- and Ku-band SATCOM, Direct Broadcast Satellite (DBS) service, International Maritime Satellite (INMARSAT), and Global Broadcast

Service (GBS) to support high data rate requirements, such as intelligence, weather, live video, news, and imagery.

ITP will place emphasis on COTS/government off-the-shelf (GOTS) components and will pursue "plug and play" modular terminal configurations. As with the Automated Digital Network System (ADNS)(described below) and DMR, the use of open systems architecture and the leveraging of commercial services and technology will reduce cost and permit rapid terminal upgrades and technology insertion. ITP will ensure compatibility with ADNS for management of RF resources.

ITP will also develop and implement multifunctional antennas, such as the Low Observable Multifunction Stack, that integrate SATCOM antennas into a single lightweight structure.

In summary, ITP capabilities, integrated with ADNS and DMR, will provide adaptable, Joint interoperable, protected, and high capacity communications at less cost.

(Ref: http://www.spawar.navy.mil/pmw176/swartc16.htm)

4.4.1.13 Automated Digital Network System:

One aspect of the Coast Guard's Internetworking Architecture (dated 1 June 1993), developed by the Internetworking Architecture Tiger Team consisting of several select Coast Guard telecommunications experts, was what they called an "intelligent gateway". Its development, they believed, would be crucial to the successful implementation of the future "network-of-networks". It was considered to be the linchpin tying the fixed shore network to the mobile sea/air network (terrestrial and space-based radio networks). The intelligent gateway was expected to become the core of the "Communication Area Master Stations (CAMS) of the future". Without this, there could never be a single writer-to-reader network.

The Navy is fielding the Automated Digital Network System (ADNS) as part of the tactical DMS implementation. It appears, from all available information, that the ADNS is the intelligent gateway. The Navy is currently fielding ADNS which will be installed at the NCTAMS and aboard all ships down to their Coastal Patrol Craft by 2003. Included in this roll-out are major Coast Guard mobile units (i.e., 378s and 270s).

The ADNS will provide efficient networking and automation capabilities, and will ensure worldwide communications connectivity via the Radio Frequency (RF) communications assets included in DMR and ITP. ADNS will leverage industry accepted standards for communications routing, switching, and management and will employ COTS/GOTS hardware and software to provide timely, efficient, and seamless data delivery to and from all data user sources (Navy, Joint and Allied).

ADNS networking capabilities will allow for the sharing of scarce communications bandwidth and will reduce reliance on "stovepipe" communications systems and dedicated bandwidth allocations. ADNS will effectively "pool" communications resources and remedy the problems caused by overloading or underutilization of communications circuits. Demonstrations and exercises, such as the JWID 95, have shown that such networking capabilities can increase utilization of communications circuits by factors of 4 to 10.

The bandwidth management and technical control automation capabilities of ADNS will provide significant payoff in terms of savings in money and manpower. Adaptation and adherence to industry standard protocols will potentially afford access to any networked INTERNETProtocol (IP) application, opening up a multitude of new opportunities, including e-mail, World Wide Web (WWW), and File Transfer Protocol (FTP).

The integration of commercial standards and COTS/GOTS hardware will significantly reduce ADNS development, procurement, and maintenance costs. Overall, ADNS maximizes information transfer efficiency and provides seamless afloat/ashore voice, video and data networks for worldwide, interoperable communications.

The special communications environments of mobile users and facilities that depend on wireless communications need to be considered. These communications are subject to jamming, noise, interference, fading, multi-path and interruption, and the protocols and access methods needed to accommodate these factors.

The evolution of technology now makes possible local storage of (potentially large) archives, and an infrastructure that supports data replication capability that can formalize and implement the replication of data among sites. Thus, careful analysis of the advantages of centralized storage with remote access needs to be compared to the advantages of local data archives that are automatically synchronized by the support infrastructure. This can be particularly true for mobile facilities where data archives can be updated on a continuing basis and available for ready reference by local users. This not only provides a potential for load-leveling on the use of communications, but assures that loss of communications will not deny access to at least segments of the critical data resources.

The advantages of a combination of both methods may also be useful where a local version of the remote data-store is updated with every query response, so that at least subsequent versions of the same query (by the same or another user) can be responded to locally.

(Ref: http://www.spawar.navy.mil/pmw176/swartc16.htm)

Table 4-11: ADNS, DMRS, ITP Comparison

Automated Digital Network System	Digital Modular Radio System	Integrated Terminal Program
Leverages Commercial Products	Builds upon common hardware, software, programmable radio technology.	Leverages commercial technology
Replaces several unique sub-networks with a single network with multimedia capabilities.	Reduces cost and increases tactical flexibility.	Introduces integrated directive antenna for topside space, weight, signature reduction.
Automates all communications systems.	Fields integrated, multiband antennas.	Pursues moeular plug-and-play terminal configurations.
Reduces development, procurement, and maintenance costs.		

Ref: http://www.spawar.navy.mil/pmw176/swartc16.htm

4.4.1.14 Application of Technologies

As stated earlier, several of the technologies in this chapter may be used in a combined effort to produce a hybrid network which will meet all of the Coast Guard's current and future voice, data, video, and interoperability requirements. Careful and accurate planning will ensure success in the future.

4.5 Technology Alternatives

Throughout the previous sections of Chapter 4, we have discussed a number of technologies that will, to varying degrees, meet certain data, mobile, or interoperability communications requirements. Individually, with consideration given to capability limitations and/or operating costs, there is no specific technology that will meet all Program Manager needs. However, by carefully selecting, analyzing, and combining several technologies into one all encompassing "network-of-networks," and thus allowing them to complement and enhance each others' capabilities, we will develop a comprehensive networking solution capable of meeting all of the Coast Guard's current and future telecommunications requirements. As discussed in the Coast Guard C4I Objective Architecture and Transition Plan, it is imperative that the ability to "quickly and easily shape information into knowledge" be provided. Telecommunications is the key technology infrastructure element which enables this to occur. For this reason, the telecommunications "network of networks" must meet the general features spelled out in the Coast Guard C4I Objective Architecture and Transition Plan for C4I infrastructure. The Coast Guard "network of networks" must be flexible, configurable, and scaleable (C4I Objective Architecture and Transition Plan items 6.3.2 & 6.5).

This section of the TCP presents a high level view of several possible networking solutions. Each alternative solution is listed below in order of precedence from the most preferred alternative to the least preferred, based on our initial capabilities assessment, technology availability, and cost analysis. After a thorough review, the Coast Guard will select up to three of these alternatives for further analysis. The results of the in-depth analysis is presented in Chapter 5 of the TCP.

The technologies contained in these alternatives are based primarily on information obtained from previous sections of the TCP (i.e., Data Communications, Mobile Communications, and Interoperability). Some technologies are currently available, some are new and emerging technologies, while others may not be available soon enough to meet the requirements of this document.

Each alternative will contain a mix of data, mobile, and interoperability technologies, which together will produce a networking solution to meet all voice, data, and video communications requirements. (Note: An asterisk (*) indicates that a particular technology can be found in each of the networking alternatives.) As new and emerging technologies evolve and are implemented, it is expected that the need for older technologies will wane. This investment in new technologies is expected to result in increased capabilities and eventual savings as the older technology is phased out. Prime examples of this are the potential for combinations of new satellite and cellular voice and data communications systems to replace current terrestrial radio systems. These terrestrial radio systems have high Coast Guard owned and maintained infrastructure costs.

Table 1, on the following page, contains a list of the technologies, described in Sections 4.1, 4.2, and 4.3 of the TCP, and also a list of the communications requirements described in Chapter 3. The Table clearly shows where certain technologies will meet specific communications requirements. Keep in mind that although a given technology is capable of meeting a specific communications requirement, cost or other factors may prohibit us from using that technology in the final networking solution. At the completion of Chapter 5 of the TCP, one networking solution will be selected as the "preferred" alternative, and planning to begin transition to this alternative will begin. However, over time, as technology updates, and changes to costs occur, another alternative may become more desirable.

This Plan primarily addresses multi-mission portions of the Coast Guard Telecommunications System (CGTS). Special purpose networks, which serve as private networks for specific Programs, and are not linked directly to the CGTS, are not addressed in detail. Examples are the Communication System (COMMSYS) Network (CSN), the Navigation Network (NAVNET), the Aviation Logistics Management Information System (ALMIS), and Intelligence Program specific networks. However, it is recognized that even though these telecommunications networks provide specific services to certain special-interest groups, they may, at a later date, be integrated into the Coast Guard Telecommunications System. The predominant concern is meeting their operational requirements within the constraints of the multimission network environment.

Other systems, not listed as an integral part of the networking alternatives, such as the Defense Information System Network (DISN), were investigated as possible networking solutions during the high-level technology analysis. These systems were not considered to be viable solutions due to one or more outstanding deciding factors. These include costs, bandwidth availability concerns, priority allocation constraints, and responsiveness to Coast Guard needs.

Table 4-12: Technology vs. Requirements

TECHNOLOGY / REQUIREMENT	One Time Data Entry	NETWORK of Networks	Form/Inform Msg Delivery	Central Data Storage & Access	Data Security	Video (1) & Imagery (2)	Interoperability	Remote Access (Dial-In)	Internal access to CG DB & Applications	Mobile Communications	Automated Chart Updates	World-wide Public Access to CG DBs	Provide Navigation Information Service	Short Range Radio Communications	Satellite Communications	Solution to Cutter Antenna Interference	User Pull	Consolidated Management Report Sys	Direction Finding Capabilities	Video Teleconferencing	Telecommuting	Open Systems Architecture	Digital Signature Standard	Telemedicine Capability	User Charge Back	Global Dial-Tone
Wide Area Networks (WANs)																										
Asynchronous Transfer Mode (ATM)	x	x	x	x		x			x				x				x	x		x	x	x		x		
Frame Relay	x	x	x	x		x2			x				x				x	x			x	x		x		
Integrated Services Digital Network (ISDN)	x	x	x	x		x		x	x				x				x	x		x	x	x		x		
Point to Point	x	x	x	x	x	x		x	x				x				x	x		x	x	x		x		
Defense Message System (DMS)		x	x		x		x																			
Commericial Satellites																										
Iridium	x	x								x	x			x	x											x
Globalstar	x	x								x	x			x	x											x
American Mobile Satellite Corporation (AMSC)	x	x	x							x	x			x	x	x										
International Maritime Satellite (INMARSAT)	x	x	x							x	x			x	x	x										
Very Small Aperture Terminal (VSAT)																										
AT&T Tridom	x	x	x			x				x				x	x	x				x		x				x
DirecPC	x	x	x			x									x		x									
Direct Broadcast Satellite		x	x				x			x					x											
Cellular Telephone																										
Cellular Digital Packet Data (CDPD)	x	x	x				x			x				x												
TDMA/CDMA/Steinbrecher Microcells	x	x	x		x		x			x				x		x						x				
CONDOR	x	x	x		x		x			x	x			x	x	x						x				
Universal Mobile Telecommunication System		x	x				x			x			x		x	x										
Global System for Mobile Communications (GSM)		x	x		x					x					x	x										x
Wireless Communications																										
Spread Spectrum Packet Radio		x	x		x	x	x			x				x												
Medium/High Frequency Communications		x	x		x		x			x			x						x							
VHF-FM							x			x				x					x							
Digital Selective Calling (DSC)														x	x				x							
NAVTEX													x	x												
SITOR			x				x			x			x	x												

Table 4-12: Technology vs. Requirements (Cont.)

TECHNOLOGY \ REQUIREMENT	One Time Data Entry	NETWORK of Networks	Form/Inform Msg Delivery	Central Data Storage & Access	Data Security	Video (1) & Imagery (2)	Interoperability	Remote Access (Dial-In)	Internal access to CG DB & Applications	Mobile Communications	Automated Chart Updates	World-wide Public Access to CG DBs	Provide Navigation Information Service	Short Range Radio Communications	Satellite Communications	Solution to Cutter Antenna Interference	User Pull	Consolidated Management Report Sys	Direction Finding Capabilities	Video Teleconferencing	Telecommuting	Open Systems Architecture	Digital Signature Standard	Telemedicine Capability	User Charge Back	Global Dial-Tone
Military Satellite Communications (MILSATCOM)																										
Defense Satellite Communications System (DSCS)		x	x				x			x																
Military Global Broadcast System (GBS)		x	x		x		x			x					x											
UHF Demand Assign Multi-Access (DAMA)		x	x				x			x					x	x										
Mini-DAMA		x	x				x			x					x	x										
Tactical DMS		x	x		x		x			x					x	x						x				
High Speed Fleet Broadcast (HSFB)		x	x		x		x			x					x	x										
Commercial Satellite Comms Inititiative (CSCI)		x	x		x		x			x					x	x										
Challenge Athena		x	x				x			x					x	x								x		
Joint Maritime Communications Strategy (JMCOMS)																										
Automated Digital Network System (ADNS)		x					x																			
Digital Modular Radio (DMR) System		x					x																			
Integrated Terminal Program (ITP)		x					x																			
Information Standards																										
Electronic Data Interchange		x	x				x			x											x	x				
Electronic Mail Exchange		x	x				x			x					x						x	x				
INTERNET		x		x				x				x	x				x				x	x				

The networking alternatives, on the following pages, are based on the Coast Guard's technology selections and Anteon Corporation's supporting recommendations. Each alternative is broken down into three major categories: data, voice, and video. The technologies are listed where they meet the requirements within each category.

4.5.1 Networking Alternative 1

Alternative 1 is a network configuration based upon proven, currently available technologies with minimum developmental risk. This configuration closely parallels the current Coast Guard Data Network (CGDN II) upgrade initiative and major DoD telecommunications architecture improvement plans.

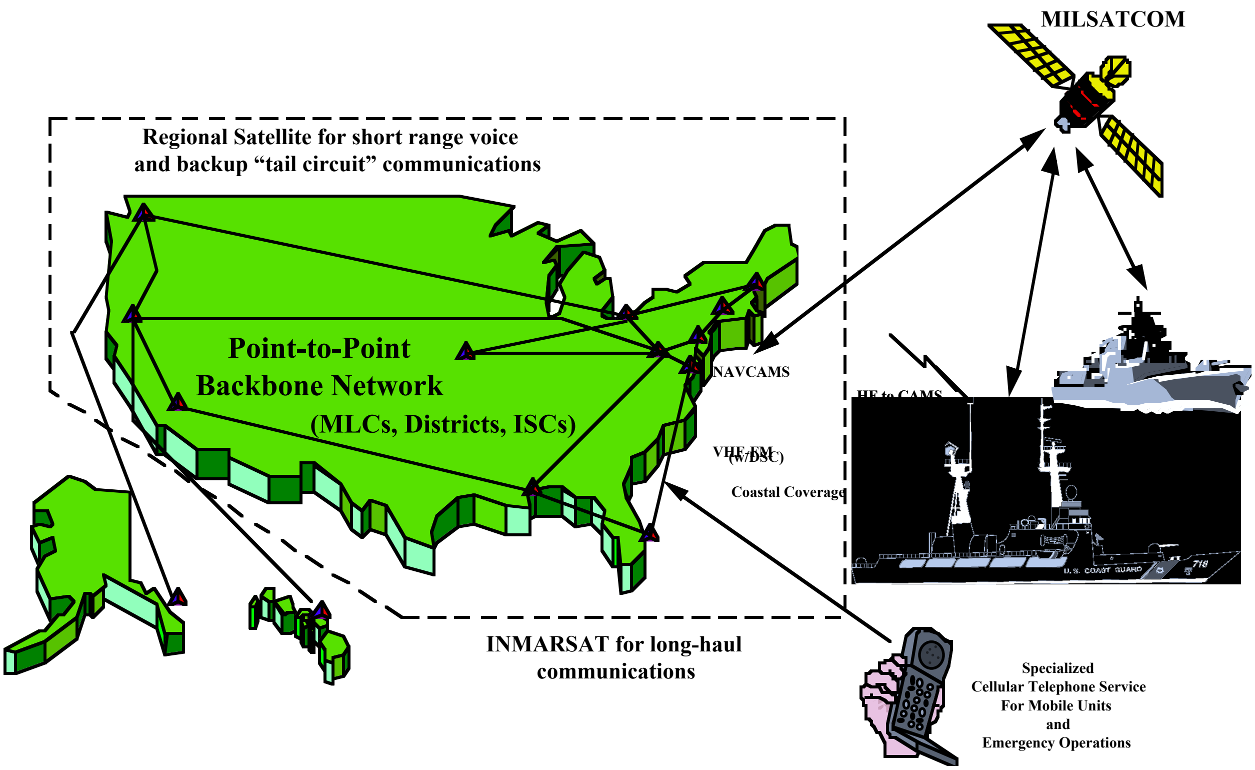


Figure 4-12: Networking Alternative #1

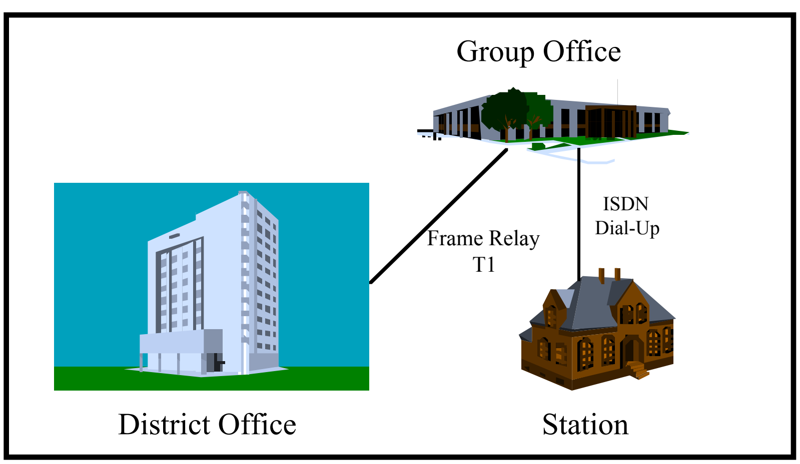


Figure 4-13: Tail Circuit

4.5.1.1 Data

The data communications portion of the Coast Guard network will consist of the following technologies:

- **<u>Point-to-Point:</u>** A T1, Point-to-Point backbone circuit, will use existing technology to link all major (Tier 1) Coast Guard units (i.e., Headquarters, Areas, MLCs, Districts, ISCs, AR&SC, FINCEN, TRACEN Petaluma, OSC Martinsburg, and other select units). These units will be linked with smaller units, in their respective regional areas, via a T1 Frame Relay service (new technology) or, in some cases, dial-up services. These circuits will use Transmission Control Protocol/INTERNET Protocol (TCP/IP). All Coast Guard units will have the capability of using INTERNET Web Browser technology and protocols in an INTERNET environment which will be used to form a Coast Guard INTRANET. E-mail will be used for internal record message transfer.

- **<u>Frame Relay:</u>** A Frame Relay T1 Intra-Coast Guard Network will connect all large (Tier 2) Coast Guard units (i.e., Groups, MSOs, Air Stations, Smaller Headquarters Units), smaller (Tier 3) units (i.e., Stations, MSDs, Recruiting Offices), and inport mobile (Tier 4) units to the Point-to-Point T1 backbone network through the major unit nodes.

- **<u>Dial-Up Integrated Services Digital Network (ISDN):</u>** ISDN Dial-Up services (new technology) may be used to connect small units to large units depending on cost and needs of the unit.

- *** <u>DMS Gateways:</u>** Gateways will provide Coast Guard access to the Defense Message System (DMS), which is an e-mail service that will run on the Defense Information System Network (DISN). (DISN is a worldwide information transfer infrastructure which includes point-to-point transmission, switched data services, video teleconferencing, etc.) There will be three gateways which will be located at OSC Martinsburg and the two MLCs. DMS services will eventually include an extension of the initial DMS network, called tactical DMS, which will allow message delivery to mobile units (378s and 270s) via satellite communications connectivity.

- *** <u>Military Satellite Communications (MILSATCOM):</u>** MILSATCOM (NAVMACS II/CUDIX/DAMA/OTCIXS) will be the primary means for ship-to-shore record message delivery. It will be used for satellite DMS and non-DMS record message and tactical data, ship-to-shore and ship-to-ship services to/from major Coast Guard mobile units (378s and 270s).

- **<u>Commercial Satellite Communications (SATCOM):</u>** Regional Satellite Systems (e.g., American Mobile Satellite Corporation (AMSC)) will be used to provide mobile units voice and data services. This may include record messaging capabilities on a secondary basis only (primary record message service will be provided by

MILSATCOM for 378s and 270s, Coast Guard satellite broadcast (LMCG) and HF for 210s, and High Frequency Data Link for 110s). (All 210s will eventually have MILSATCOM receive capabilities, and it is expected that, as satellite communications costs decrease, 110s will shift from HFDL to commercial SATCOM services.) The primary use of commercial satellite service will be underway mobile unit access to Mission Essential Applications (i.e., FLS, SARMIS, LEIS-II, etc.) and voice communications between cutters and operational commanders.

INMARSAT Commercial Satellite services will be used by mobile units located outside of the Regional Satellite System coverage area. This may be necessary in just a few instances. Redundant systems can be minimized. SARSAT will also continue to monitor distress alerts from 121.5 MHz and 406 MHz emergency position-indicating radio beacons (EPIRB).

- **MF/HF Radio Communications:** HF radio communications systems will be used for Radioteletype (RATT) broadcasts and on-call/full-termination service, as needed, and data link (HFDL) communications services for non-satellite equipped mobile units (110s, WLBs, etc.). (HF, for Coast Guard command and control, will eventually be phased out and replaced with military or commercial SATCOM services.) It will continue to be used as a backup to satellite communications for 378s and 270s. HF interface to the public will be maintained by Simplex Teletype Over Radio (SITOR), and with HF Digital Selective Calling (DSC) capabilities which will be required on certain shore stations and cutters to comply with the Global Maritime Distress and Safety System (GMDSS). MF will continue to be used for Navigational Telex (NAVTEX) and 2MHz distress guard services for the maritime public.

- **INTERNET:** INTERNET access for the public will be provided through a single gateway located at a single site (i.e., OSC Martinsburg). A “firewall” will provide the safeguards needed to protect Coast Guard internal systems from unauthorized access. Meanwhile, Coast Guard “Home Pages” will be maintained to give the public appropriate information synopsized or extracted from service-wide databases.

4.5.1.2 Voice

- **VHF-FM:** VHF-FM radio communications will continue to be used for providing maritime information broadcasts and for meeting National Distress System (NDS) service requirements at shore units and on mobile units. It will also be used for ship-to-ship and ship-to-shore command and control communications for on-scene operations, and for maintaining interoperability with the Navy and other law enforcement agencies. VHF-FM Digital Selective Calling (DSC) service will also be provided by the Coast Guard under the GMDSS. The National Distress System modernization project is studying alternatives to VHF-FM, emerging technologies to augment or replace VHF-FM, and better interfaces to the Coast Guard Telecommunications System.

- **<u>MF/HF Radio Communications:</u>** HF radio communications will continue to provide ship-to-ship, ship-to-shore, and air-to-ground voice communications (i.e., SAR and L/E operations, etc.). As satellite communications become more available and less costly to use, HF communications may assume a back-up roll in the Coast Guard communication system. MF communications will continue to provide 2MHz distress guard services for the maritime public.

- **<u>MILSATCOM:</u>** MILSATCOM services will be used to provide tactical voice communications services for satellite equipped Coast Guard mobile units (i.e., 378s and 270s);

- **<u>Commercial SATCOM:</u>** Regional Satellite (e.g., AMSC) voice services will provide coverage of the CONUS and coastal maritime areas for shore-based and mobile Coast Guard units;

  INMARSAT telephone service will provide satellite voice communications outside of the Regional Satellite Service prime coverage areas; and

- **<u>Cellular Telephone:</u>** Specialized cellular telephone services (e.g., CONDOR capable cellular/satellite telephones) will be used for emergency communications, and administrative and operational voice communications within the CONUS and CONUS Exclusive Economic Zone (EEZ) for land-based mobile units. This service will provide an interoperable link with many other agencies. FBI, DEA, and DoD are making significant commitments to CONDOR which has capability for either covered or protected communications.

4.5.1.3 Video

- **<u>Public Switched Telephone Network (PSTN):</u>** Video requirements will be met using ISDN dial-up service via the Public Switched Telephone Network (PSTN).

Table 4-13: Networking Alternative #1

ALTERNATIVE 1 / TECHNOLOGY	REQUIREMENT	One Time Data Entry	NETWORK of Networks	Form/Inform Msg Delivery	Central Data Storage & Access	Data Security	Video (1) & Imagery (2)	Interoperability	Remote Access (Dial-In)	Internal access to CG DB & Applications	Mobile Communications	Automated Chart Updates	World-wide Public Access to CG DBs	Provide Navigation Information Service	Short Range Radio Communications	Satellite Communications	Solution to Cutter Antenna Interference	User Pull	Consolidated Management Report Sys	Direction Finding Capabilities	Video Teleconferencing	Telecommuting	Open Systems Architecture	Digital Signature Standard	Telemedicine Capability	User Charge Back	Global Dial-Tone
Wide Area Networks (WANs)																											
Frame Relay		x	x	x	x		x2			x				x				x	x			x	x		x		
Integrated Services Digital Network (ISDN)		x	x	x	x		x		x	x				x				x	x		x	x	x		x		
Point to Point		x	x	x	x	x	x		x	x				x				x	x		x	x	x		x		
Defense Message System (DMS)			x	x		x		x																			
Commericial Satellites																											
American Mobile Satellite Corporation (AMSC)		x	x	x							x	x			x	x	x										
International Maritime Satellite (INMARSAT)		x	x	x							x	x			x	x	x										
Cellular Telephone																											
CONDOR		x	x	x		x		x			x	x			x	x	x						x				
Wireless Communications																											
Medium/High Frequency Communications			x	x		x		x			x			x						x							
VHF-FM								x			x				x					x							
Digital Selective Calling (DSC)															x	x				x							
NAVTEX														x	x												
SITOR				x				x			x			x	x												
Military Satellite Communications (MILSATCOM)																											
Defense Satellite Communications System (DSCS)			x	x				x			x																
Military Global Broadcast System (GBS)			x	x		x		x			x					x							x				
UHF Demand Assign Multi-Access (DAMA)			x	x				x			x					x	x										
Mini-DAMA			x	x				x			x					x	x										
Tactical DMS			x	x		x		x			x					x	x						x				
High Speed Fleet Broadcast (HSFB)			x	x		x		x			x					x	x										
Joint Maritime Communications Strategy (JMCOMS)																											
Automated Digital Network System (ADNS)			x	x				x																			
Digital Modular Radio (DMR) System			x	x				x																			
Integrated Terminal Program (ITP)			x	x				x																			
Information Standards																											
Electronic Data Interchange			x	x				x			x											x	x				
Electronic Mail Exchange			x	x				x			x					x						x	x				
INTERNET			x		x				x				x	x				x									

4.5.2 Networking Technology 2

Alternative 2 is based upon high-probability of success technologies being deployed in the near future. These technologies are anticipated to provide significant opportunities to improve Coast Guard communications processes and meet all Coast Guard future voice, data, and video requirements.

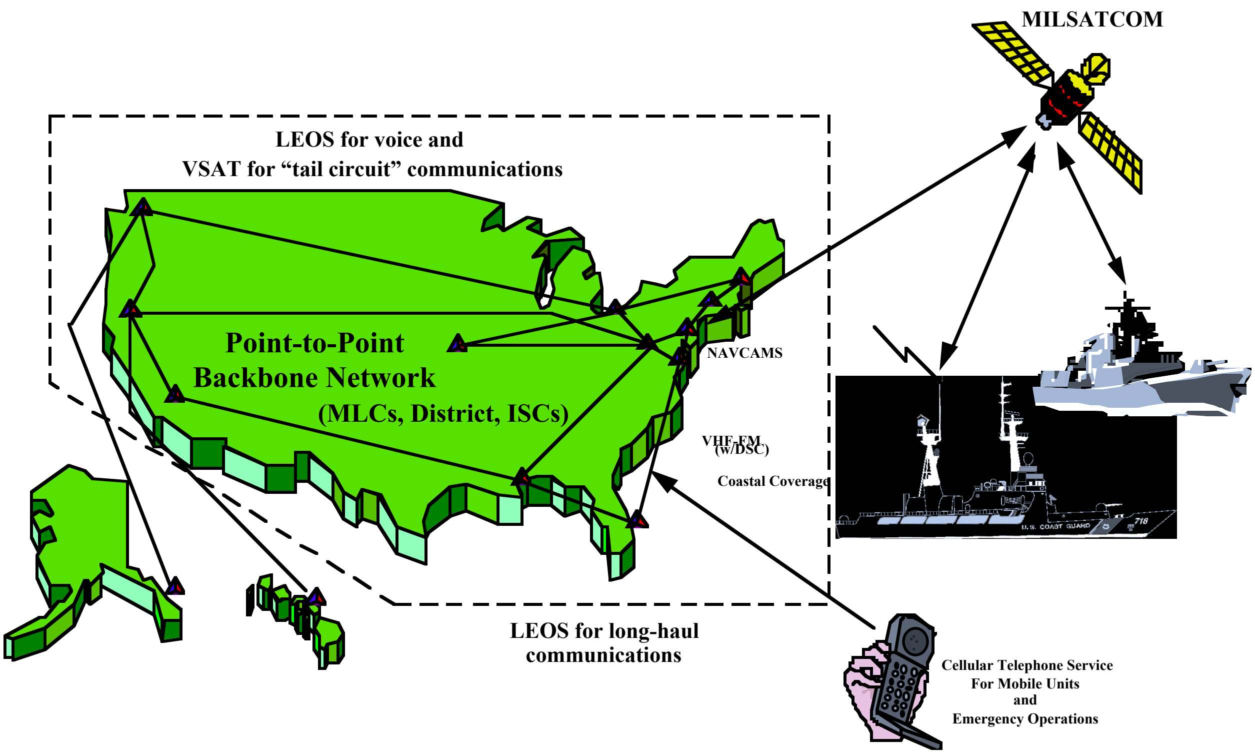


Figure 4-14: Networking Alternative #2

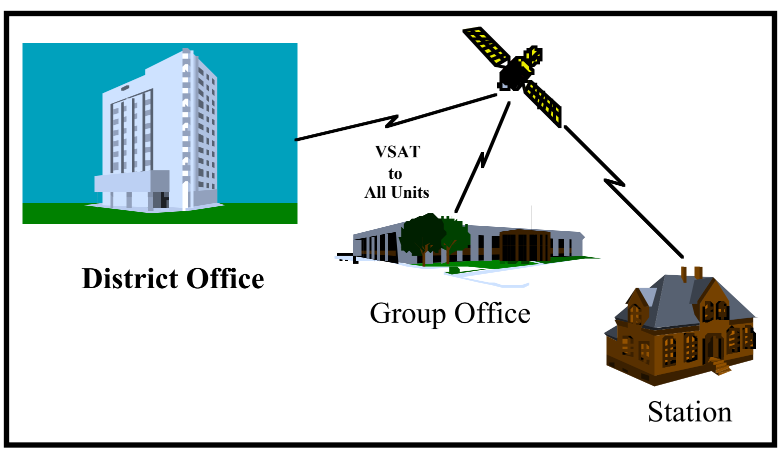


Figure 4-15: Tail Circuit

4.5.2.1 Data

- **Point-to-Point:** A T1 Point-to-Point backbone circuit, using TCP/IP, will link all Tier 1 units. These units will be linked with Tier 2 and 3 units via commercial SATCOM services. (See commercial SATCOM paragraph, below, for tail circuit architecture.) These circuits will use TCP/IP giving all units the capability of using INTERNET Web Browser technology and protocols in an INTERNET environment which will be used to form a Coast Guard INTRANET.

- **DMS Gateways:** Gateways will provide Coast Guard access to the Defense Message System (DMS), which is an e-mail service that will run on the Defense Information System Network (DISN). (DISN is a worldwide information transfer infrastructure which includes point-to-point transmission, switched data services, video teleconferencing, etc.) There will be three gateways which will be located at OSC Martinsburg and the two MLCs. DMS services will eventually include an extension of the initial DMS network, called tactical DMS, which will allow message delivery to mobile units (378s and 270s) via satellite communications connectivity.

- **MILSATCOM:** MILSATCOM (NAVMACS II/CUDIX/DAMA/OTCIXS) will be used for satellite DMS and non-DMS record message and tactical data, ship-to-shore and ship-to-ship services to/from major Coast Guard mobile units (378s and 270s);

- **Commercial SATCOM:** Very Small Aperture Terminal (VSAT) (2-way) (e.g., AT&T Tridom or Hughes DirecPC) satellite services will be used for data communications within the CONUS and CONUS Exclusive Economic Zone (EEZ). Global Low Earth Orbit Satellite (LEOS) services (e.g. IRIDIUM, Globalstar) will be used for communications outside the CONUS EEZ. This may include record messaging capabilities on a secondary basis only (primary record message service will be provided by MILSATCOM for 378s and 270s, Coast Guard satellite broadcast (LMCG) and HF for 210s, and High Frequency Data Link (HFDL for 110s). Commercial SATCOM systems are potential technologies to replace HFDL et al. However, they will need to be deployed, proven, and cost effective before a final analysis could be completed. The primary use of the commercial satellite service will be underway mobile unit access to Mission Essential Applications (i.e., FLS, SARMIS, LEIS-II, etc.) and voice communications between cutters and operational commanders.

- **MF/HF Radio Communications:** HF radio communications systems will be used for Radioteletype (RATT) broadcasts and on-call/full-termination service, as needed, and data link (HFDL) communications services for non-satellite equipped mobile units (110s, WLBs, etc.). HF interface to the public will be maintained by Simplex Teletype Over Radio (SITOR), and with HF Digital Selective Calling (DSC) capabilities which will be required on certain shore stations and cutters to comply with the GMDSS. MF will be used for Navigational Telex (NAVTEX) and 2MHz distress guard services for the maritime public.

- **INTERNET:** INTERNET access for the public will be provided through a single gateway located at a single site (i.e., OSC Martinsburg). A "firewall" will provide the safeguards needed to protect Coast Guard internal systems from unauthorized access. Meanwhile, Coast Guard "Home Pages" will be maintained to give the public appropriate information synopsized from service-wide databases.

4.5.2.2 Voice

- **VHF-FM:** VHF-FM radio communications will continue to be used for providing maritime information broadcasts and for meeting National Distress System (NDS) service requirements at shore units and on mobile units. It will also be used for ship-to-ship and ship-to-shore command and control communications for on-scene operations, and for maintaining interoperability with the Navy and other law enforcement agencies. VHF-FM Digital Selective Calling (DSC) service will also be provided by the Coast Guard under the Global Maritime Distress and Safety System (GMDSS). The National Distress System modernization project is studying alternatives to VHF-FM, and interfaces to the Coast Guard Telecommunications System will be considered.

- **MF/HF Radio Communications:** HF radio communications will continue to provide ship-to-ship, ship-to-shore, and air-to-ground voice communications (i.e., SAR and L/E operations, etc.). As satellite communications become more available and less costly to use, HF communications may assume a back-up roll in the Coast Guard communication system. MF communications will continue to provide 2MHz distress guard services for the maritime public.

- **MILSATCOM:** MILSATCOM services will be used to provide tactical voice communications services for satellite equipped Coast Guard mobile units (i.e., 378s and 270s).

- **Commercial SATCOM:** Low Earth Orbit (LEO) (new) satellite technology, such as Globalstar (or equivalent service) will be the system of choice for voice communications worldwide.

- **Cellular Telephone Service:** The existing Advanced Mobile Phone System (AMPS) cellular infrastructure will be used for emergency communications, and administrative and operational voice communications within the CONUS and CONUS Exclusive Economic Zone (EEZ) for land-based mobile units. This service may also provide interoperability with many local law enforcement agencies (i.e., FBI, DEA).

4.5.2.3 Video

- **Public Switched Telephone Network (PSTN):** Video requirements will be met using ISDN dial-up service via the Public Switched Telephone Network (PSTN)

Table 4-14: Networking Alternative #2

ALTERNATIVE 2 / TECHNOLOGY	REQUIREMENT	One Time Data Entry	NETWORK of Networks	Form/Inform Msg Delivery	Central Data Storage & Access	Data Security	Video (1) & Imagery (2)	Interoperability	Remote Access (Dial-In)	Internal access to CG DB & Applications	Mobile Communications	Automated Chart Updates	World-wide Public Access to CG DBs	Provide Navigation Information Service	Short Range Radio Communications	Satellite Communications	Solution to Cutter Antenna Interference	User Pull	Consolidated Management Report Sys	Direction Finding Capabilities	Video Teleconferencing	Telecommuting	Open Systems Architecture	Digital Signature Standard	Telemedicine Capability	User Charge Back	Global Dial-Tone
Wide Area Networks (WANs)																											
Point to Point		x	x	x	x	x	x		x	x				x				x	x		x	x	x		x		
Defense Message System (DMS)			x	x		x		x																			
Commericial Satellites																											
Globalstar		x	x								x	x			x	x											x
Very Small Aperture Terminal (VSAT)																											
DirecPC		x	x	x			x									x		x									
Cellular Telephone																											
Standard cellular			x					x			x							x									
Wireless Communications																											
Medium/High Frequency Communications			x	x		x		x			x			x					x								
VHF-FM								x			x				x				x								
Digital Selective Calling (DSC)															x	x				x							
NAVTEX														x	x												
SITOR				x				x			x			x	x												
Military Satellite Communications (MILSATCOM)																											
Defense Satellite Communications System (DSCS)			x	x				x			x																
Military Global Broadcast System (GBS)			x	x		x		x			x					x											
UHF Demand Assign Multi-Access (DAMA)			x	x				x			x					x	x										
Mini-DAMA			x	x				x			x					x	x										
Tactical DMS			x	x		x		x			x					x	x						x				
High Speed Fleet Broadcast (HSFB)			x	x		x		x			x					x	x										
Joint Maritime Communications Strategy (JMCOMS)																											
Automated Digital Network System (ADNS)			x					x																			
Digital Modular Radio (DMR) System			x					x																			
Integrated Terminal Program (ITP)			x					x																			
Information Standards																											
Electronic Data Interchange			x	x				x			x											x	x				
Electronic Mail Exchange			x	x				x			x					x						x	x				
INTERNET			x		x				x				x	x				x									

4.5.3 Networking Technology 3

Alternative 3 includes other potential high impact technologies which are available or anticipated and have not been considered in Alternative 1 or 2. In comparison to the other alternatives, Alternative 3, in using several emerging and not currently available technologies, may appear less desirable as a preferred alternative. However, in the future, this may be the network of choice, when these technologies impose less risk and better service at reduced cost.

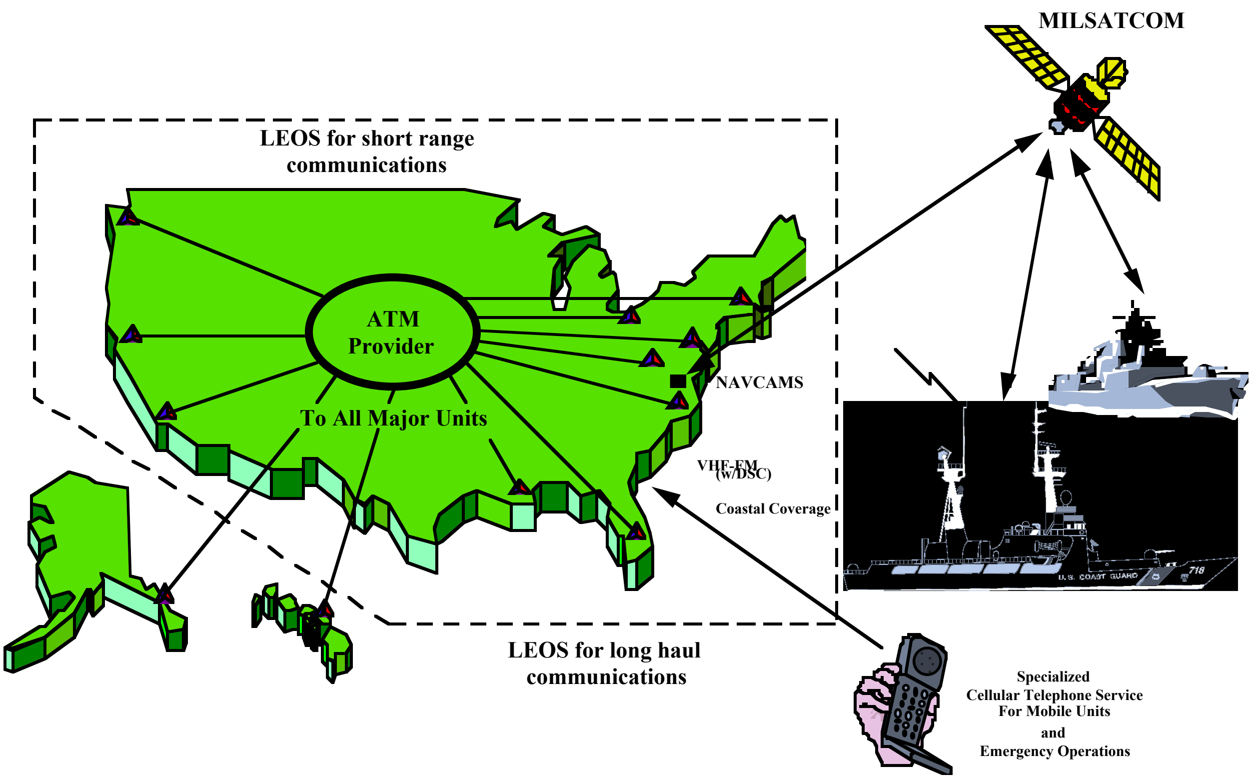


Figure 4-16: Networking Alternative #3

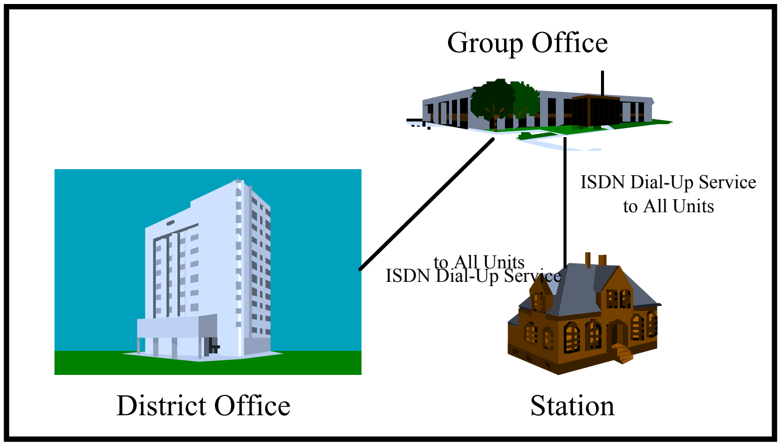


Figure 4-17: Tail Circuit

4.5.3.1 Data

The data communications portion of this networking solution will consist of the following technologies:

- **<u>Asynchronous Transfer Mode (ATM):</u>** An ATM T1 Backbone (emerging technology) Intra-Coast Guard Network will link all Tier 1 units. These units will be further connected to smaller (Tier 1 and 2) units, located in their respective regional areas, via ISDN Dial-Up services. All Coast Guard units will have the capability of using INTERNET Web Browser technology and protocols in an INTERNET environment which will be used to form a Coast Guard INTRANET. E-mail will be used for record message transfer;

- **<u>ISDN Dial-Up:</u>** ISDN services (new technology) will be used for all units at and below the Tier 1 level. Tier 2 and 3 units will connect to the ATM backbone network through the ISDN service at the Tier 1 unit nodes.

- **<u>DMS Gateways:</u>** Gateways will provide Coast Guard access to the Defense Message System (DMS), which is an e-mail service that will run on the Defense Information System Network (DISN). (DISN is a worldwide information transfer infrastructure which includes point-to-point transmission, switched data services, video teleconferencing, etc.) There will be three gateways which will be located at OSC Martinsburg and the two MLCs. DMS services will eventually include an extension of the initial DMS network, called tactical DMS, which will allow message delivery to mobile units (378s and 270s) via satellite communications connectivity.

- **<u>Military Satellite Communications (MILSATCOM):</u>** MILSATCOM (NAVMACS II/CUDIX/DAMA/OTCIXS) will be used for satellite DMS and non-DMS record message and tactical data, ship-to-shore and ship-to-ship services to/from major Coast Guard mobile units (378s and 270s);

- **Commercial Satellite Communications (SATCOM):** Low Earth Orbit Satellite (LEOS) services (e.g., IRIDIUM, Globalstar) will provide global voice and data coverage for mobile units. This may include record messaging capabilities on a primary basis for smaller cutters, such as 110s and WLBs, and on a secondary or tertiary basis only for larger cutters (i.e., the primary means of record message service will be MILSATCOM for 378s, 270s, and 210s). The primary use of this satellite service will be to provide underway mobile units access to Mission Essential Applications (i.e., FLS, SARMIS, LEIS-II, etc.). SARSAT will also continue be used to monitor distress alerts from 121.5 MHz and 406 MHz emergency position-indicating radio beacons (EPIRB).

- **MF/HF Radio Communications:** HF radio communications systems will be used for Radioteletype (RATT) broadcasts and on-call/full-termination service, as needed, and data link (HFDL) communications services for non-satellite equipped mobile units (110s, WLBs, etc.). (HF, for Coast Guard command and control, will eventually be phased out and replaced with military and/or commercial SATCOM services.) It will continue to be used as a backup to satellite communications for 378s and 270s. HF interface to the public will be maintained by Simplex Teletype Over Radio (SITOR), and with HF Digital Selective Calling (DSC) capabilities which will be required on certain shore stations and cutters to comply with the Global Maritime Distress and Safety System (GMDSS). MF will continue to be used for Navigational Telex (NAVTEX) and 2MHz distress guard services for the maritime public.

- **INTERNET:** INTERNET access for the public will be provided through a single gateway located at a single site (i.e., OSC Martinsburg). A “firewall” will provide the safeguards needed to protect Coast Guard internal systems from unauthorized access. Meanwhile, Coast Guard “Home Pages” will be maintained to give the public appropriate information synopsized from service-wide databases.

4.5.3.2 Voice

- **VHF-FM:** VHF-FM radio communications will continue to be used for providing maritime information broadcasts and for meeting National Distress System (NDS) service requirements at shore units and on mobile units. It may also continue to be the least costly means for ship-to-ship and ship-to-shore command and control communications for on-scene operations, and for maintaining interoperability with the Navy and other law enforcement agencies. Otherwise, a CONDOR capable cellular system will be used as the primary means of voice communications for Coast Guard command and control. VHF-FM Digital Selective Calling (DSC) service will also be provided by the Coast Guard under the Global Maritime Distress and Safety System (GMDSS). The National Distress System modernization project is studying alternatives to VHF-FM, and interfaces to the Coast Guard Telecommunications System will be considered.

- **MF/HF Radio Communications:** HF radio communications will continue to provide ship-to-ship, ship-to-shore, and air-to-ground voice communications (i.e., SAR and L/E operations, etc.). As satellite communications become more available and less costly to use, HF communications may assume a back-up roll in the Coast Guard communications system. MF communications will continue to provide 2MHz distress guard services for the maritime public.

- **MILSATCOM:** MILSATCOM services will be used to provide tactical voice communications services for satellite equipped Coast Guard mobile units (i.e., 378s and 270s).

- **Commercial SATCOM:** LEOS voice services (e.g., IRIDIUM, Globalstar) will provide coverage of the CONUS and coastal maritime areas for shore-based and mobile Coast Guard units. LEOSs can also be used world-wide for voice communications, as needed by mobile and shore units;

- **Cellular Phone Service:** Specialized cellular telephone services (e.g., CONDOR capable cellular/satellite telephones) will be used for emergency communications, and short-haul administrative and operational voice communications for land-based mobile units. This service will provide an interoperable link with many other agencies. FBI, DEA, and DoD are making significant commitments to CONDOR which has capability for either covered or protected communications.

4.5.3.3 Video

- **Public Switched Telephone Network (PSTN):** Video requirements will be met using ISDN dial-up service via the Public Switched Telephone Network (PSTN)

Table 4-15: Networking Alternative #3

ALTERNATIVE 3 / TECHNOLOGY \ REQUIREMENT	One Time Data Entry	NETWORK of Networks	Form/Inform Msg Delivery	Central Data Storage & Access	Data Security	Video (1) & Imagery (2)	Interoperability	Remote Access (Dial-In)	Internal access to CG DB & Applications	Mobile Communications	Automated Chart Updates	World-wide Public Access to CG DBs	Provide Navigation Information Service	Short Range Radio Communications	Satellite Communications	Solution to Cutter Antenna Interference	User Pull	Consolidated Management Report Sys	Direction Finding Capabilities	Video Teleconferencing	Telecommuting	Open Systems Architecture	Digital Signature Standard	Telemedicine Capability	User Charge Back	Global Dial-Tone
Wide Area Networks (WANs)																										
Asynchronous Transfer Mode (ATM)	x	x	x	x		x			x				x				x	x		x	x	x		x		
Integrated Services Digital Network (ISDN)	x	x	x	x		x		x	x				x				x	x		x	x	x		x		
Defense Message System (DMS)		x	x		x		x																			
Commericial Satellites																										
Iridium	x	x								x	x			x	x											x
Cellular Telephone																										
Condor	x	x	x		x		x			x	x			x		x	x					x				
Wireless Communications																										
Medium/High Frequency Communications		x	x		x		x			x			x						x							
VHF-FM							x			x				x					x							
Digital Selective Calling (DSC)														x	x				x							
NAVTEX													x	x												
SITOR			x				x			x			x	x												
Military Satellite Communications (MILSATCOM)																										
Defense Satellite Communications System (DSCS)		x	x				x			x																
Military Global Broadcast System (GBS)		x	x		x		x			x					x											
UHF Demand Assign Multi-Access (DAMA)		x	x				x			x					x	x										
Mini-DAMA		x	x				x			x					x	x										
Tactical DMS		x	x		x		x			x					x	x						x				
High Speed Fleet Broadcast (HSFB)		x	x		x		x			x					x	x										
Joint Maritime Communications Strategy (JMCOMS)																										
Automated Digital Network System (ADNS)		x					x																			
Digital Modular Radio (DMR) System		x					x																			
Integrated Terminal Program (ITP)		x					x																			
Information Standards																										
Electronic Data Interchange		x	x				x			x											x	x				
Electronic Mail Exchange		x	x				x			x					x						x	x				
INTERNET		x		x				x				x	x				x									

Table 4-16 shows the technologies selected for each alternative to form a hybrid networking solution that will meet all Coast Guard voice, data, and video service requirements.

Table 4-16: Networking Alternatives

Alternative	Systems and Units	#1	#2	#3
Data	CGDN+ Tier 1 Backbone	Point-to-Point	Point-to-Point	ATM
	CGDN+ Tier 2	Frame Relay	VSAT	
	CGDN+ Tier 3/4	Dial-up ISDN	VSAT	ISDN Dial-Up
	Tactical DMS to 378's/270's, DOD trfc for all others	DMS Gateways	DMS Gateways	DMS Gateways
	Tactical/record msg trfc to 378's/270's, LMCG to 210s	MILSATCOM	MILSATCOM	MILSATCOM
	MEAs to all units	Commercial SATCOM - Regional Satellite - Inmarsat	Commercial SATCOM - VSAT - LEOS	Commercial SATCOM - LEOS
	GMDSS reqt/sat backup to mobile units, HFDL WPB/WLB	MF/HF Radio Comms	MF/HF Radio Comms	MF/HF Radio Comms
	Public	INTERNET	INTERNET	INTERNET
Voice	Shore ops/mobile, distress/C3	VHF-FM	VHF-FM	VHF-FM
	GMDSS reqt/sat backup	MF/HF Radio Comms	MF/HF Radio Comms	MF/HF Radio Comms
	Tactical voice on 378/270's	MILSATCOM	MILSATCOM	MILSATCOM
	Admin and C3 voice for shore and mobile units	Commercial SATCOM - Regional Satellite - Inmarsat	Commercial SATCOM - LEOS	Commercial SATCOM - LEOS
	Emerg, admin and C3 comms for shore and mobile units	CONDOR	Cellular Service	CONDOR
Video	All units with terrestial connection	PSTN	PSTN	PSTN

4.5.4 Summary

In this chapter of the TCP, an analysis was conducted of three technologies, selected by the Coast Guard, to determine their potential for addressing current and future requirements and their impacts on the Coast Guard's future architecture. These technologies were Data, Mobile, and Interoperability. The initial analysis was kept to a high level to present only a broad view of technologies that are available, or will be available, that may meet Coast Guard voice, data, and video requirements. From the results of this analysis, three example networking solutions were developed and presented in the final section of this Chapter. Each of these solutions will meet all current and future Coast Guard voice, data, and video requirements. However, the technologies vary in capability and cost, and range from currently available existing technologies to new and emerging technologies where future availability and costs are unknown.

The first alternative is a network configuration based primarily upon proven, currently available technologies with minimum developmental risk. It consists of several data and voice technologies that combined will meet all record message, mission essential application, and tactical communications needs. These technologies include Point-to-Point and Frame Relay technology, with ISDN dial-up capabilities where needed; and MILSATCOM, Commercial SATCOM, and traditional MF/HF for wireless communications support.

The second alternative is based upon high-probability of success technologies being deployed in the near future. (These technologies are anticipated to provide significant opportunities to improve Coast Guard communications processes.) This alternative is similar to Alternative 1, however, SATCOM is used more extensively to meet shore-side and wireless communications requirements.

The third alternative includes other potential high impact technologies, such as ATM, which are available or anticipated and have not been considered in Alternative 1 or 2.